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GENERAL FISHERIES COUNCIL FOR THE MEDITERRANEAN

Fourth Session of the

TECHNICAL CONSULTATION ON STOCK ASSESSMENT IN THE EASTERN MEDITERRANEAN

Thessaloniki, Greece, 7-10 October 1991

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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PREPARATION OF THIS DOCUMENT

This the final report adopted by the participants in the Fourth Session of the Technical Consultation on Stock Assessment in the Eastern Mediterranean. The document also includes papers presented at the session. The bibliographic references have been included as presented by the authors.

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ABSTRACT

The meeting reviewed progress made in the assessment of stocks in the Eastern Mediterranean since 1988. Scientists from Cyprus, Greece and Israel presented technical papers covering various aspects of the Eastern Mediterranean fisheries, i.e., fishing effort, resources magnitude and management, fisheries development prospects and research. The Consultation noted with satisfaction the measures taken by some countries aiming at a better control on fishing effort and requested that close monitoring of the impact of such measures on the resources be maintained. The status of the environment in the Eastern Mediterranean and its impact on the fisheries were also reviewed. The concern of GFCM regarding changes and degradation of the marine environment and ecosystems, based on the rapid eutrophication of the Black Sea that led to the deterioration of the fisheries in that region and which also threatens the Sea of Marmora and the Aegean Sea, was emphasized. The consultation took note of the apparent increasing trend in recruitment of swordfish over recent years and called for further investigation and monitoring, and continued standardized sampling with application of age estimation procedures. The need for coordinated management of bluefin tuna was also proposed by the meeting. With regard to small pelagic stocks, it is noted that while the sardine stocks are underfished, those of anchovy are heavily exploited. Specialists from the region are facing difficulties in suggesting proper management of the demersal stocks in that area, the use of yield modelling needs substantial adaptation to meet the nature and structure of the fish population.

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I. OPENING OF THE CONSULTATION AND ARRANGEMENTS FOR THE SESSION

1. The Third Technical Consultation on Stock Assessment in the Eastern Mediterranean of the General Fisheries Council for the Mediterranean (GFCM) was held in the Congress Hall, International Fair of Thessaloniki from 7 to 10 October 1991 under the chairmanship of Mr. N. Tsimenides, Chairman of GFCM. It was attended by 30 participants from three GFCM member countries and one observer from Italy. The list of participants is given in Appendix 2 to the report.

2. Mr. N. Tzivanidis, Technical Advisor to the Minister of Agriculture, opened the Consultation by welcoming the participants and wishing them success in their work.

3. Mr. H. Ben Alaya, Secretary of GFCM, welcomed the participants on behalf of FAO. He noted that the last Technical Consultation had left the impression of an increasing development in the Eastern Mediterranean fisheries. He mentioned possibilities of cooperation in the area and reviewed the major recommendations of the Second Technical Consultation and action taken for their implementation by the Member Nations and FAO.

II. ADOPTION OF THE AGENDA

4. The Consultation adopted the Agenda shown in Appendix 1. The documents submitted to the Consultation are listed in Appendix 3.

III. ELECTION OF OFFICERS

5. Mrs. Olga Agiovlassiti (Greece) was elected Chairperson of the Consultation and Mr.N. Hadjistephanou (Cyprus) Vice-Chairman.

IV. NATIONAL REPORTS ON DEVELOPMENTS IN THE FISHERIES SINCE THE SECOND TECHNICAL CONSULTATION

CYPRUS

A. The fleet

(a) **Artisanal fisheries (for the year 1989)**

6. The fleet consists of 624 boats of 3-13 m (lOA), of which:

217 are full-time boats
139 are part-time boats
268 are occasional boats

7. A of 1 402 fishermen are engaged in the artisanal fishery as follows:

444 are full-time fishermen
314 are part-time fishermen
548 are occasional fishermen

(b) **Industrial fisheries** (demersal)

8. This fishery consists of 10 trawlers of 17.3-28.4 m (LOA), of 210-600 HP Diesel engines. All of them are sterntrawlers, with steel or wooden hull.

9. In addition to one trawler fishing in international waters, 4 to 6 other trawlers licensed for Cyprus water are also fishing in international waters during the closed season (June-October).

(c) **Industrial fisheries** (pelagic)

10. This fishery is engaged only in swordfish fishing. The fleet consists mainly of small artisanal-type boats. They operate from April to October.

(d) **Fish production**

11. The total fish production is as follows:

1984	1985	1986	1987	1988	1989
465 040	482 950	499 390	481 960	491 740	510 380

GREECE

A. Evolution of fisheries in Greece during recent years

12. During the last three years (1988-90) sea fisheries production, from the Mediterranean and over seas, remains rather stable and is estimated at 150 000 t. The evolution of fisheries production from 1986 to 1990 is reproduced in Table 1.

TABLE 1

EVOLUTION OF GREEK FISHERIES PRODUCTION DURING
1986, 1987, 1988, 1989 AND 1990

Year Branches	1986 tx10	1987 tx10	1988 tx10	1989 tx10	1990 tx10
Mediterranean waters	114.2	123	130.4	132.4	132.4
Atlantic waters	17.3	19.2	21.2	19.6	17.2
TOTAL	131.5	142.2	151.6	152	149.6

B. Review of the fishing fleet

13. The fishing fleet can be divided into three main categories:

(a) vessels for overseas fisheries
(b) vessels for large-scale fisheries
(c) vessels for small-scale fisheries.

14. Vessels of the first category operate out of the Mediterranean. They produce 14 percent of the total fisheries production. Vessels of the two other categories operate in the territorial waters or in the Mediterranean. They are of two types: large-scale fishery vessels (54 percent of total production) and small-scale fishing vessels (32 percent of total production).

C. Resource management

15. The Greek Government adopted the following measures:

(i) no new licences have been issued since 1988, except in the case of replacement of an existing vessel with a new one of the same or smaller capacity and horsepower;

(ii) significant financial incentives are given to encourage withdrawal of fishing vessels, including small inshore fishing boats;

(iii) closed fishing seasons and closed fishing grounds regulations have been implemented. Measures to regulate type of gear and equipment for each fisheries are being considered;

(iv) present restrictions for the fishing gear "ypi-ypi" (seiners) have been extended farther off shore. Similarly, the number of fishing days have been reduced.

D. Perspectives regarding fisheries development

16. Within the framework of EEC recommendations and regulations and towards a more rational resource management, the following strategy is being implemented.

- "Mixed" (joint) companies are to be formed between Greek and non-EEC parties in order to obtain access to new fishing grounds;

- renewal and modernization of the fleet continues, in order to achieve an equilibrium between fishing capacity and stock, and to improve the working conditions of those involved in the sector;

- decrease of the fleet capacity;

- early retirement for fishermen;

- strengthening of cooperation with neighbouring countries in the Mediterrnean are for a coordinated fisheries management and resources exploitation.

ISRAEL (Fisheries in 1988)

The Mediterranean fisheries

17. The trawl fishery, carried out by 23 trawlers and 5 mini-trawlers (vessels of less than 13 m) provided about 1 600 t of fish, 200 t more than the previous year, due mainly to a marked increase in the total fishing effort (from 5 533 fishing-days in 1987 to 6 064 in 1988). The value of the catch amounted to US$6.5 million, 28.7 percent more than the value of the 1987 catches. This was due mainly to the increase of the quantity of the total trawl catches, but also to a slight increase in average prices.

18. The purse-seine fishery, carried out by 26 small boats, provided about 1 070 t of pelagic fish, of which 307 t of sardines which, not many years ago has been the main product of this fishery. The steady decrease in sardine catches is due to the fact that local canneries prefer to process imported raw material. The value of the purse-seine catches amounted to US$3.2 million.

19. The inshore fishery in the Mediterranean, carried out by more than 300 boats of up to 10 m fishing by bottom-set longlines and by various types of bottom-set and floating entangling gear, provided about 1 300 t fish, of which nearly 590 t were of prime quality, mostly groupers and snappers. The small inshore fishery in the Red Sea (at Elat) contributed another 130 t of fish, caught mostly by fish traps and barrier nets.

20. The value of the in-shore catches amounted to slightly more than US$7.8 million, some US$0.6 million more than in 1987, in spite of the fact that the volume of catches was nearly the same in both years.

Fish consumption

21. Fish consumption in Israel is calculated on the base of the weight of fish and fishery products as they reach the consumer. Some 68 413 t of fish and fishery products reached the Israeli market, of which 42 712 t where imported. Per caput consumption increased slightly, reaching 14.8 kg as against 13.6 kg in 1987.

Research and development

22. Research and technical development activities carried out during 1988 by the staff of the Department of Fisheries, in cooperation with researchers from other institutions or agencies, are as follows:

23. The Fishing Technology Unit (FTU) conducted a survey in Lake Kinneret as part of an ecological impact study connected to the planned construction of a pumped-storage hydro/electric plant. The survey involved the collection of information on fish distribution.

24. Other activities of the FTU were:

- training of fishermen to promote their professional proficiency, through courses in trawling technology in cooperation with the Fisheries Unions;
- monitoring of artificial reefs, established in 1988.

25. The updated figures on landed catches for 1989 and 1990 are not yet available. There is almost no difference between last year's figures and those of previous years.

Discussion of the national reports

26 The Consultation noted the steady progress being made in Cyprus with rationalization of the fisheries regulations and effort control, and requested that a more extensive review of the recent events following the "Cyprus effect" described by Garcia and Demotropoulos (1986 - Management of Cyprus Fisheries, FAO Fish.Tech.Pap. 250:43 p.) be provided at the next Consultation, noting that this example has provided the motivation for seasonal closures such as have been successfully applied elsewhere in the Mediterranean (e.g., Italy) in subsequent years. Clarification was also requested on the statistics, which appear to show both increasing effort and increasing catch rates in the trawl and artisanal fisheries. It was suggested that the diversion of effort into the swordfish fishery may have been responsible for this apparent anomaly.

27. In relation to the Greek national report, it was noted that efforts are being made to reduce fishing pressure and total number of licences in the fishery. There is another issue under consideration by the fisheries authorities. It consists of deploying the fishing fleet by statistical area in relation with the productivity of each area instead of the present licensing system which gives the right to licensed fishing boats to operate anywhere in the Greek waters. It is hoped that such arrangements would allow an accurate evaluation of the fishing pressure and its impact by fishing area and thus a finer tuning of the fisheries policy.

28. The Israeli national report admitted the difficulties being faced by the Israeli fisheries authorities in obtaining scientific advice on fish resources from the expertise that exists outside the Government sector in applied fisheries and marine research. The Consultation also showed concern about the lack of up to date information on the occurrence of new Indo-Pacific species entering the Mediterranean from the Red Sea, which, according to available information, appear first in the Israeli and Egyptian fisheries before moving westwards and northwards into the rest of the Mediterranean.

V. ENVIRONMENTAL STUDIES IN FISHERIES OF THE EASTERN MEDITERRANEAN

29. Two papers on environmental issues of interest to fisheries were presented. They noted the overriding influence of the Black Sea outflow in determining the seasonal thermal and salinity structure of the water masses, as well as the distribution of nutrients.

30. Apart from an unknown proportion of nutrients entering the euphotic zone from river runoff, especially from major rivers along the northern and eastern coasts of the Aegean, and from anthropogenically-caused runoff in the bays adjacent to large cities, the major nutrient inputs to the Eastern Mediterranean now come from the Black Sea outflow. The other significant source of nutrients, especially in the southern and eastern Aegean comes from standing gyres, whose existence has been described by the cooperative oceanographic programme, POEM, and from temporary wind-driven upwellings.

31. Despite seasonal variations, the southerly and easterly Aegean region is typically under the domination of the northerly-flowing Levantine surface water, which forces the low-salinity, nutrient-enriched outflow from the Black Sea to flow down the whole eastern coastline of the mainland of Greece.

32. One consequence of this which is of extreme importance to understanding Aegean fisheries, is that a high proportion of fisheries production comes from eutrophic coastal bays and lagoons along the northern and western shores of the Aegean Sea. Thus Stergiou et al. (Annex 2 of Appendix 3), note that the four subareas of Greek waters with the highest production of Mullidae (numbered 13, 14, 17 and 10 in the figure), all lie along the northern and western sides of the Aegean Sea. In contrast, the southerly and easterly Aegean is characterized by generally highly oligotrophic conditions.

33. The Secretariat explained that the priority now being given to environmental issues in all FAO bodies reflected the Organization's concern with issues of environmental change and degradation of the marine environment and ecosystems, which is the theme of a major UN conference in 1992: the United Nations Conference on the Environment and Development (UNCED). The recent issue of GFCM Studies and Reviews No. 63 has provided strong indications that eutrophic effects due to anthropogenically-caused nutrient inputs to the Mediterranean and Black Seas, in conjunction with over-fishing, have had disastrous effects on the latter semi-enclosed sea, and have also had significant impacts on the Mediterranean.

34. Under FAO's Regular Programme, studies have been commissioned in which both the environment and the renewable resources have been discussed together: the first two of this series were presented in draft form: those by Kocatas et al. on the Sea of Marmara, and by Bingel et al. for the North Levantine Basin will be published in a forthcoming issue of GFCM "Studies and Reviews". Both studies have particular interest for the present Consultation. Other relevant studies in this series that have been invited, are a Russian study on the Sea of Azov, and one on the long term consequences of the Aswan High Dam on Mediterranean fisheries.

35. This last study will focus, among other topics, on the flow of Indo-Pacific species into the Mediterranean, which is, at least in part, a consequence of the reduced Nile outflow. The Consultation recognized the advantage of a closer monitoring of this situation, in which the Israeli and Egyptian fisheries may provide the first indications of new species that may appear elsewhere in the Mediterranean at a later stage.

36. The desirability of complementing these studies by a similar review for the Aegean Sea, including Cretan waters, was recognized by the Consultation, which recommended FAO to arrange for such a study to be conducted.

37. A further use of satellite imagery to provide information in relation to fisheries was provided by a presentation by Gazis et al., who used bathymetry to provide a mapping of shallow shelf areas in the eastern Aegean.

VI. PROGRESS IN THE EVALUATION OF LARGE PELAGIC RESOURCES

38. The paper by Tserpes and Tsimenides (Annex 3, Appendix 3) was discussed under this heading. The main Greek fishery for large pelagics began some 10 years ago, and that for swordfish, the most important,has now spread to encompass two main fishing areas; one based on the port of Chania, to the north of Crete, the other from Kalymnos, whichhas progressively spread eastwards into the Levant region and south towards the Egyptian coast.

39. Discussion centred on possible stock structure. In the absence of tagging experiments, which are recommended by the Consultation, the little information available comes from preliminary genetic studies which suggest a difference between Atlantic and Mediterranean stocks, and which may increase (in one genetic component) with distance east from Gibraltar. The question of the possible separation of Mediterranean and Atlantic stocks remains to be established however, as does the question of the degree to which migratory behaviour affects stock structure.

40. The suggestion made by ICCAT, that for the Atlantic there may have been a generally increasing trend in recruitment over recent years, appears to be supported by Italian data, but this will be difficult to establish in the absence of age composition data until the expansion phase of the fishery is completed. This hypothesis is an interesting one, and, if true, may imply either a general trend upwards in pelagic production, or a hypothetical decline in intraspecific competition, caused by the capture of many of the older individuals.

41. The Consultation called for continued standardized sampling of the swordfish landings, with, where possible, application of age estimation procedures for the samples.

42. Concern was expressed over the state of the swordfish stock, and the need for international coordination of management action. Evidence was presented from the GFCM database that both swordfish and albacore landings in the Mediterranean increased dramatically after 1984, and this appears to be due to the intensification of the fishery, and the introduction of large-scale pelagic gear in several of the larger fisheries. There seems to be evidence of a slight decline in catch rates by the Cyprus fleet, at least since 1985 (Annexe 1, Appendix 3). For Greek fisheries at least, the albacore catch trend holds stable.

43. The Consultation noted that GFCM member countries non-members of ICCAT should be aware of management recommendations promulgated by that Commission in 1991 for swordfish, and in particular the suggested minimum size limit of 25 kg.

44. Attention was also drawn to the need to consider coordinated management of bluefin tuna regulations, and non-member countries of ICCAT are reminded of the new management recommendations recently proposed by that body.

VII. PROGRESS IN EVALUATION OF SMALL PELAGIC FISHERY RESOURCES

45. Anchovy stocks make up a significant proportion of national landings by value in Greek waters, and there is concern with the current state of the stock, which is fished by a large fleet based in the Northern Aegean and composed of purse-seiners (lamparas) and trawlers. As elsewhere in the Mediterranean, there are indications of stock decline in recent years, and technical measures have been implemented in Greece to reduce fishing power (restrictions on number and power of lights and reduction of fishing season length and fishing days). Acoustic surveys suggested an exploitation rate of 0.3 for the central Aegean which seems sustainable. However, the reason for the fear of overexploitation is not due to a specific assessment (given that CPUE data are not a good index of abundance for schooling fish). More to the point is that landings have not kept pace with the increase of fishing power in the small pelagic fisheries in the 1970s and 1980s.

46. In contrast, the sardine stock is largely underfished due to low market demand. Catch trends for horse mackerel are generally upwards.

47. The apparent collapse of the anchovy stock in the Black Sea in recent years was mentioned. Although the Pontic anchovy has been considered a separate subspecies, it would be interesting to know what contribution, if any, of fish eggs and larvae have come from the Black Sea and Sea of Marmara to the Aegean Sea. It is also interesting to note that this stock collapse is not considered to be entirely due to overfishing, although this may have played a part. A major role may be ascribed to massive blooms of pelagic hydrozoans which are predators on fish eggs and larvae. It is also important to monitor the abundance of Medusae and ctenophores in the upper Aegean, given that these species which preyon fish eggs and larvae have been implicated in the decline of Black Sea pelagic stocks. A report on the abundance of coelenterates and other related aspects of the Black Sea outflow, was requested for the next Consultation.

VIII. PROGRESS IN EVALUATION OF DEMERSAL FINFISH RESOURCES

48. Many papers were presented on this topic (see Table 1); some of these are included in the annexes. Issues that arose in relation to a number of the papers are as follows:

(a) Subregional variations and stock structure of Aegean demersal fisheries

49. Several papers, and notably that by Stergiou on Cepola sp. (Annex 2 (Appendix 3), illustrated the clear differences in both population parameters and management advice that can arise in adjacent bays, island shelves, or other subareas. This situation may result in sub-stocks separated by highly oligotrophic waters which may be largely inhospitable to

passive dispersal of larval stages of many coastal species due to food limitation. The question was raised as to what are the management units or stocks which should ideally be managed separately, and what degree of genetic and/or ontogenic separation may exist between population centres. The very practical question was also raised as to whether management measures, including effort control and licence allocation, should be specifically set for such sub-areas.

50. The Consultation positively to this question, especially if a common management regime could lead to effort being over-concentrated in a few areas to the detriment of very productive stocks in these areas. This question of stock identity for practical management purposes appears to be a priority area for investigation by Aegean scientists in the immediate future. It also offers great potential for the comparative approach in contrasting scientific results, especially from nutrient-enriched and oligotrophic areas.

(b) Parameter estimation

51. The estimation of growth parameters still continues to pose serious problems in stock assessment in this Mediterranean sub-region (Annexes 4, 8 and 9, Appendix 3), and can be summarized under the following headings:

(i) Growth: the exclusive use of the von Bertalanffy growth function as a description of growth in length has constrained the assessment approaches used, and it is clear that for several species this growth model does not describe well the first two years of life when growth is very fast, before approaching a plateau at older ages. The Technical Secretary noted that using a vector of mean weights at age, as in the ICES area, would be a more appropriate research strategy, as mentioned in the report of the last Consultation. Age-C reading problems arose in relation to red mullet that appear to call for a standardization of approaches . This may require a special meeting including, ideally, experts on Mullidae from the rest of the Mediterranean.

(ii) Natural Mortality: There does not seem to be any easy alternative to the use of Pauly's formula for adult M, although some of the predictions resulting from its use appear to be inappropriate, and a comparison with results from other species, or the same species in other areas, would seem to be necessary before carrying out the calculations over a range of reasonable M values. The other problem relates to the question of the appropriate values of M to use for 0+ and 1+ age groups. The experience from the MS VPA (Virtual Population Analysis) experiments in the North Sea (see, e.g., Spurholt, H. 1990: J. du Conseil Vol. 46(2), p. 211-23) suggests that 0+ and 1+ M values must be set significantly higher than for the adults, at (say) 1-2+ for 0+ age groups, and (say) 0.75 to 1+ for age 1+ (These values are only intended to be indicative, and are not necessarily recommended values).

(c) Yield modelling

52. Since one of the possible applications of the yield per recruit model is in considering changes in size at first capture, and these relate to the first two years of life, a model based on von Bertalanffy growth functions have doubtful application, except possibly for predicting the changes in fishing mortality on the adults. The Technical Secretary suggested that the use

of the constant parameter, Beverton and Holt yield per recruit formulation, which depends on steady-state conditions and single parameter values, may not be entirely appropriate for the Mediterranean region, for reasons mentioned earlier in this report. The Consultation felt that the strategy mentioned in an Annex to the previous consultation is still valid: this is based on a vector of mean weights at age, and a series of recruitment estimates, to use the Thompson Bell approach to yield forecasting, in which yield is summed over different age classes, with appropriate parameters used for each (see Ricker, W.E., 1975. Bull.Fish.Res.Bd., Canada 191:382 p). The approach to production modelling for Aegean Greek fisheries mentioned in Stergiou et al. was felt to be promising, once problems of effort standardization such as were encountered in an earlier study for the Gulf of Lions, have been overcome (see FAO Rapport sur les pêches No. 386). The two approaches to cohort analysis and VPA (Hadjistephanou for four demersal species off Cyprus), and by Petrakis et al. for Aegean hake are promising if unconventional approaches. They do, however, depend heavily on the constant recruitment assumption, given that they back-calculate over different year-classes. These approaches should be applied to the same cohort for a series of years in the conventional fashion, once several more years of data became available.

(d) Monitoring biomass and recruitment

53. The absence of a regular series of data on biomass and recruitment, especially for the demersal stocks, is seen as an impediment to a serious long-term approach to assessment of the marine resources. Such an approach requires both ongoing programmes of biological statistics collection in the main ports, surveys by (fine mesh) for demersal recruitment, monitoring and by acoustics for the small pelagics, and ideally, permanent personnel for age reading and data handling and storage. At present, few countries in the Eastern Mediterranean have the facilities and funds to provide these services, which are regarded as a high priority by the Consultation. One of the reasons for this state of affairs was explained to result from the short-term nature of funding for fisheries research, which is dispersed over a range of subjects. The Consultation stressed that the provision of adequate long-term core funding should be regarded as a priority.

54. A report on the cephalopod fauna of the upper Aegean was presented by D'Onghia et al. Annex 5, A high diversity of species was noted, many of which are not represented in landings, and others not correctly designated in the fishery statistics.

IX. PROGRESS IN FISHERY MANAGEMENT AND COMMON POLICY ISSUES

(a) Evolution of an assessment strategy for Eastern Mediterranean stocks

55. The work on stock assessment in the Eastern Mediterranean has shown steady progress, from an initial emphasis on biological description of the resources and the use of "short-cut" methods, for providing "guesstimates" of the state of the resources. More emphasis is now being placed on age-reading techniques, which has been the classical approach followed, e.g., by researchers in Cyprus. A heavy dependence on fitting von Bertalanffy growth curves is still apparent. This differs from the approach adopted in the Northern Atlantic where assessments are carried out using vectors of weight at age, based on observations at several intervals in the first year(s) of life. The use of von Bertalanffy parameter values in a Beverton and Holt yield per recruit calculation, is again of doubtful

relevance to management of age 0+ and 1+ individuals, where the benefits of management are the greatest (see, e.g., Garcia and Demetropoulos, 1986), the pooling of several years of data on the assumption of a steady-state situation continuing is sometimes necessary, but will lose information on trend in abundance which is of prime importance, particularly if there is evidence, or concern, that the environment may be changing, as is the case for example in the Mediterrenean area.

56. Heavy emphasis is still being placed on occasional sampling and on short-time series of data, which are only fully applicable if it is believed that a steady-state situation prevails. These are few time series of survey data, or even regular sampling schemes for the commercial catch, which would allow a continuity of information on that most important variable, the level of annual recruitment.

57. Information on recruitment trends which would allow a degree of forecasting of fishing trend might be obtained by a regular fine mesh survey of nursery areas several time per year. Retrospectively, cohort analysis of commercial catches may allow some valuation of previous recruitment trends of species now fully recruited to the fishery.

58. The Committee reviewed the activities of the Scientific and Techncial Committee for Fisheries (STCF) of the European Community as presented in its meeting in Fano, italy (May 1991). This meeting which was attended by some GFCM member countries and by the Technical Secretary of GFCM suggested that considerable progress can be made if STCF and GFCM Technical Consultations on Stock Assessment can agree on a common database and approach.

59. The STCF has carried out several activities since 1980, including the following:

- Annual reviews of the fishery resources
- Advice on technical measures on fisheries management
- Fisheries in an ecological context
- Ad hoc questions
- General policy.

60. One deficiency recognized to date in the activities of the STCF has been the relatively low input of socio-economic data, of particular concern in the Mediterranean context, into its management decisions. On the other hand, the greater rigour used in collecting standard resource data, and the longer time period over which assessments have been carried out in the North Sea and Atlantic, have allowed more definite management conclusions to be reached.

61. Since the EEC members of GFCM will in future be working with the standardized forms, it appears that these could be an useful basis for GFCM work.

62. the Consultation was advised of the Secretariat's intention to develop the SPECIESDAB data base as a recipient for stock assessment information based on the data in the FAO Species Identification Sheets for Fisheries Purposes for the Mediterranean, and requested interested organizations to contact the Technical Secretary.

(b) Progress in management and policy issues

63. The three countries represented at the Consultation have all taken, or propose to take, measures towards better management of their fisheries, but a general constraint in all cases is the limited availability of information and reseach to support these decisions. In the case of Cyprus, a significant cut in the size of the small-scale fleet is being implemented.

64. Technical measures such as reduced fishing seasons (also being implemented in Cyprus) are aimed at reducing fishing power. In Greece, moves to meet with EEC guidlines for fleet reduction are being implemented; programmes are aimed at providing alternative employment for displaced fishermen. Regional and local fishery offices will be set up with the aim to improve collection of fishing statistics and biological studies whose present poor quality is one constraint to the current system of stock assessment.

65. The Consultation recognized the importance of reconciling the work of GFCM with that of the STCF group of the EEC, and recommended that this matter be discussed at the next meeting of the Committee on Fisheries Management of the GFCM.

X. ANY OTHER MATTERS

66. In general, the recommendation of the last Consultation, that there should be a special workshop on statistical data collection and analysis proceedures in the subregion, is still of interest, and FAO is requested to find a way of implementing this recommendation in the next intersessional period.

67. The need for a workshop to discuss a comparative study of commercial species of Mullidae on a Mediterranean-wide basis, as was attempted for hake and sardine by the Mallorca meeting), was felt to be a priority that should be recommended to the Committee on Fisheries Management of GFCM. The requirement was to prepare a summary of biological data before such a meeting was raised, and it was suggested by the Technical Secretary that the SPECIESDAB database, now being developed for the Mediterranean, will include a population dynamics module where the results of earlier assessments for each species can be stored, and used as a database for such a meeting.

68. The representatives of Cyprus and Israel suggested that, in order to improve attendance at the Technical Consultations on Stock Assessment in the Eastern Mediterranean, the Secretariat should send at the beginning of every year a tentative list of meetings scheduled for the year, being understood that the venue and the date of such meetings are subject to changes.

69. The representative of Cyprus suggested that a training course for stock assessment specialists be arranged in a GFCM member country. It was mentioned that should universities in the region be prepared to organize such training courses with visiting lecturers funded by regional organizations, lectures, the Council might be prepared to sponsor such courses.

70. The Consultation agreed that donors such as EEC might be requested to finance such training courses for scientists from all GFCM member countries.

71. A final concern expressed by all participants concerned the poor attendance for the second consecutive time at this Consultation. It was noted that improving research and fisheries management is presumably a priority for all member countries of the region, and the Secretary was asked to bring this concern to the notice of those countries (Egypt, Lebanon, Syria, Turkey) who did not send representatives, in the hope that they will be able to contribute to the success of the next Consultation.

72. The Consultation recommended that the Council consider the possibility of a broader geographic coverage for future Eastern Mediterranean Counsultations which might also include the Black Sea.

XII. DATE AND PLACE OF THE NEXT CONSULTATION

73. Since no invitation has been received from countries represented in the Consultation to host the next meeting, the Consultation agreed to retain FAO Headquarters in Rome as a tentative venue. However, the Consultation requested the Secretary to continue investigating the possibility of holding the future Session of the Consultation in the region, and to consult with the concerned member countries in order to determine a date for the next session.

APPENDIX 1

AGENDA

1. Opening of the Session
2. Arrangements for the Session
3. Adoption of the Agenda
4. Designation of Chairman and Vice/Chairman
5. National reports on developments in the fisheries since the Second Technical Consultation
6. Progress in evaluation of large pelagic fish resources
    - 6.1 Catch and effort statistics
    - 6.2 Parameters estimates
    - 6.3 Evaluation of stocks
7. Progress in evaluation of demersal finfish resources
    - 7.1 Catch and effort statistics
    - 7.2 Parameters estimates
    - 7.3 Evaluation of stocks
    - 7.4 Trawl surveys
8. Hydrological and environmental studies
9. Progress in evaluation of small pelagic fish resources
    - 9.1 Catch and effort statistics
    - 9.2 Parameters estimates
    - 9.3 Evaluation of stocks
    - 9.4 Acoustic surveys
10. Progress in fisheries management and common policy issues
11. Any other matters
12. Date and place of the next meeting
13. Adoption of the report

APPEMDIX 2

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APPENDIX 3

LIST OF DOCUMENTS

Annex 1.	Assessment of Five Demersal Marine Fish Stocks of Cyprus for the Year 1989, by N. A. Hadjistephanou, Ministry of Agriculture and Natural Resources, Department of Fisheries, Nicosia
Annex 2.	Geographic Variations in Biological Parameters of Red Bandfish, Cepola macrophthalma, in the Western Aegean Sea: Implications for Fisheries Management in the Eastern Mediterranean, by Konstantinos I. Stergiou, National Centre for Marine Reearch, Agios Kosmas, hellinikon, 16604 Athens
Annex 3.	The Swordfish Fishery in the Aegean Sea; Analysis of Size Data Collected From 196-1990 by G. Tserpes (Institute of Marine Biology of Crete, P.O. Box 2214 71003, Iraklion) and N. Tsimenides (University of Crete, Department of Biology, Iraklion)
Annex 4.	Age, Growth and State of Stock of Red Mullet (Mullus barbatus L., 1758) in the Saronikos Gulf of Greece by Napoleon Vrantzas, Marika Kalagia and Constantina Karlou, Ministry of Agriculture, Fisheries Laboratory, Piraeus
Annex 5.	Teuthofauna of the North Aegean Sea: Preliminary Results on Catch, Composition and Distribution, by G. D'honghia, A. Tursi, C. Papaconstantinou and A. Matarrese
Annex 6.	Preliminary Biological Data of the Striped Mullet (Mullus surmuletus) in the Aegean Sea, by V. Vassilopoulou and C. Papaconstantinou, National Centre for Marine Research, Hellinikon, 16604
Annex 7.	The Mullidae (Mullus barbatus, M. surmuletus) Fishery in Greek Waters, 1964-1986, by K.I. Stergiou, G. Petrakis and C. Papaconstantinou, National Center for Marine Research, Hellinikon, 16604
Annex 8.	Aspects of the Biology and Dynamics of Red Mullet (Mullus barbatus) in the Aegean Sea, by V. Vassilopoulou and C. Papaconstantinou, National Centre for Marine Reearch, Hellinikon, 16604
Annex 9.	Preliminary Study on the Bilogy of Piper (Trigla lyra L., 1758) in the Aegean Sea, by C. Papaconstantinou, G. Petrakis, E. Caragitsou and Ch. Mytilineou, National Centre for Marine Research, Hellenikon, 16604
Annex 10.	A Premilinary Study on the Fishery Biology of Hake in the egean Sea, by C. Papaconstantinou, G. Petrakis and A. Fourtouni, National Centre for Marine Research, Hellenikon, 16604

Annex 11. Ichthyoplankton Distribution in the Aegean Sea in Summer 1990, by E. Caragitsou, A. Siapatis, A. Economou and C. Papaconstantinou, National Centre for Marine Research, Hellenikon, 16604

Annex 12. Virtual Population Analysis and Cohort Analysis of Hake in the North Aegean Sea, by G. Petrakis, C. Papaconstantinou and K.I. Stergiou, National Centre for Marine Research, Hellenikon, 16604

ANNEX 1

ASSESSMENT OF FIVE DEMERSAL MARINE FISH STOCKS OF CYPRUS FOR THE YEAR 1989

by

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Abstract

Five of the most important fish species landed in Cyprus are Mullus surmuletus, M. barbatus, Spicara smaris, Boops boops and Pagellus erythrinus. The population dynamics of these five species have been investigated in order to evaluate their stocks for the year 1989.

The results have shown that the stocks of all five species of this study are overexploited in various degrees. Overfishing is leading the stocks of P. erythrinus into an extremely dangerous situation of probable exhaustion; the stocks of S. smaris are following the fate of the pandora, while the stocks of the remaining three species are also endangered.

INTRODUCTION

Five of the most important fish species landed by trawl and inshore fisheries in Cyprus are:

Mullus surmuletus	(Barbouni - striped red mullet)
Mullus barbatus	(Strilia - red mullet)
Spicara smaris	(Marida - picarel)
Boops boops	(Voppa - bogue)
Pagellus erythrinus	(Lithrini - pandora)

The population dynamics of these species have been investigated in order to evaluate their stocks for the year 1989, that is, from November 1988 to October 1989. The results were compared to those for the previous three years; useful conclusions were derived and measures were suggested to improve the stocks.

MATERIALS AND METHODS

Concerning the inshore fishery, length distributions of the five species were recorded from the catches of the private boats. Data concerning the trawl fishery were mainly collected from the catch of the research vessel TRITON; those taken from the commercial trawlers were a small proportion of the whole collection. The data were collected by irregular visits to the fishing stations or trips with TRITON and commercial trawlers.

Data on the quantities caught from each species were obtained from the Statistics and Record Section of the Department of Fisheries. The biological parameters of each species are taken from Livadas (1986).

RESULTS

The age cohort analysis for 1989, i.e., November 1988 to October 1989, for the five species, Mullus surmuletus, M. barbatus, Spicara smaris, Boops boops and Pagellus erythrinus for both the trawl and inshore fisheries are given on Table 1, 2, 3, 4 and 5 respectively. Tables 1 and 1a show a complete example of the steps followed in order to obtain the yield-per-recruit for M. surmuletus from the annual length distribution. The same procedure was followed for all other species.

The yield-per-recruit values as well as fishing mortality (F) for the five species are tabulated in Table 6 for the last four years. Table 7 shows the values of two important parameters of the species for the same period, i.e., the total mortality (Z) and ratio of exploitation (E) for the years 1986 to 1989.

The calculated stock, the predicted yield and the reported total catch for each species for the years 1986-89 are given in Table 8.

DISCUSSION

From the Age Cohort Analysis (Tables 1 to 5) it can be seen that, with the exception of Spicara smaris, only 6 age-groups (of the 10-12 originally present in the catch 25 years ago) appear in the catches of the species under review. This is a sign of overfishing, also indicated by Livadas (1987, 1988).

As it appears from the column of the total instantaneous mortality rate due to fishing, the values of (F) are bigger for the older age-groups. In the age-group 4 (F) values reach 1.31 for M. surmuletus, 2.21 for B. boops, 2.56 for P. erythrinus and 2.77 for M. barbatus. This means that heavy fishing is practised on the existing older age-group, that is, the bigger fish of the stock are caught and therefore the stock is hard-pressed to maintain even fewer age-groups than the existing.

It is useful to note that for the O-group of B. boops the (F) value is practically zero (Table 4). This means that voppa is recruited at age 1; that is, another age group is absent from its catch but for a very different reason in this case.

The fluctuations of the yield-per-recruit and the fishing mortality values for four years are shown in Table 6 for all the species. From Table 6 it is observed that a lower fluctuation of the yield-per-recruit values appears for M. surmuletus followed by S. smaris. These species are predicted to have a more or less stable yield in the last four years.

The values of F corresponding to the optimum Y/R at tc = 0.5 for the species of this study are as follows:

Mullus surmuletus	F: 0.6 = 18.7 g
M. barbatus	F: 0.4 = 18.7 g
Spicara smaris	F: 0.4 = 7.6 g
Boops boops	F: 0.4 = 29.2 g
Pagellus erythrinus	F: 0.4 = 8.1 g

For 1989 the F for M. surmuletus and S. smaris are within the optimum values of Y/R (see Table 6). In order to achieve the best Y/R, the F for the other three species must be decreased to F = 0.4 for M. barbatus from F = 1.01, for B. boops from F = 0.75 and for P. erythrinus from F = 0.85.

In order to reduce fishing mortality F to the desired level, Livadas (1986) indicated two alternatives:

(a) to reduce the fishing effort of the fishing vessels and
(b) to increase the size of the cod-end mesh of trawlers.

Discussing the latter alternative, Livadas (1986) explains that the cod-end size will be reduced to a size that will retain in the trawl-net fish of not less than 1-year-old. He points out that this is feasible for M. surmuletus, M. barbatus, B. boops and P. erythrinus, i.e., fish with larger girth, but it is not feasible for Spicara smaris, which will escape through the larger meshes of the new cod-end. It is concluded that this method of reducing F is not advisable because picarel, being the basic catch of the trawl fishery, will be drastically reduced in the catch and therefore the trawl fishery as a whole will not survive.

The total mortality (Z) and the ratio of exploitation (E) are shown in Table 7 for the period 1986-89. Although the total mortality values fluctuate greatly, they can be collectively described as high.

A ratio of exploitation of fish stocks (E) over 0.50 indicates a risk of overexploitation. The ratio of exploitation of all five species examined has high values, this being a mathematical expression of high risk for overexploitation of the species. Even the less exploited species, S. smaris, has an E value near 0.6 for 1989.

The values of the stock, the predicted yield and the catch for the five species in the years 1985-89 are shown in Table 8. From this table these three important parameters can be followed for each species separately. When the annual catch of a stock is lower than its predicted annual yield, i.e., C/Y < 1, the situation of the stocks is more or less healthy, because the stocks continue to build up. This is true for M. surmuletus, M. barbatus and B. boops.

The situation is opposite when C/Y > 1. This happens in the case of P. erythrinus; the catch is greater than the predicted yield of this species for the last three years. This means that for the previous three years a proportion of the catch consists of the mother stock. If this situation is true, P. erythrinus may be commercially extinct in the waters of Cyprus.

More alarming, however, is the fact that a similar situation appears for S. smaris. During the period 1986-90 the predicted yield and stock of picarel are almost the same in quantities; predicted yield is higher than the catch in 1986 and 1988; the catch is greater than the predicted yield in 1987 and 1989. This situation is very disturbing because picarel is the basic catch of the trawl fishery.

It has been shown that the stocks of all five species of this study are overexploited in various degrees. Overfishing is leading the stocks of P. erythrinus into an extremely dangerous state of probable exhaustion; the stocks of S. smaris are following the fate of the pandora, while the stocks of barbouni, strilia and voppa can hardly avoid the same fortune.

Corrective measures must be introduced to save the stocks. The measures recommended by Livadas (1987) are hereby adopted, and are the following:

(a) to encourage the trawlers now fishing in the territorial waters to fish in international waters for as long as possible during each fishing season, by providing subsidies and other incentives, or to fish in territorial waters only from November to February (avoiding the months of fish reproduction) for 2 years, to allow the stocks to recuperate

(b) to introduce at the same time alternating closed areas for 2-year periods (Livadas, 1987)

At the same time two other suggestions must be seriously considered:

(a) to draw up a more efficient sampling programme, and

(b) to conduct experiments on the cod-end mesh size, aiming to divide the fishing season into two periods.

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Table 1

Age cohort analysis for the species Mullus surmuletus in 1989

Age groups	Numbers caught C_t	Numbers attaining each age N_t	$S_t = e^{Z_t}$	Z_t	F_t	Average numbers in sea	Weight Kg
0	257 700	11 230 723	0.69	0.38	0.028	9 297 089	90 182
1	1 827 345	7 697 829	0.51	0.68	0.33	5 598 879	114 217
2	2 112 559	3 890 591	0.25	1.39	1.04	2 102 403	68 118
3	504 932	968 251	0.27	1.32	0.97	537 731	27 586
4	158 338	258 446	0.19	1.66	1.31	126 048	6 466
5 and older	24 603	49 206			0.35 *		
	4 885 477	24 095 046		1.09	0.74	17 662 150	306 569

Parameters

$M = 0.35$ $e^{m/2} = 1.191246$

$K = 0.103$ $t_o = -3.24$ $L^{\infty} = 33.2$ cm $W^{\infty} = 5.06$ g

$t_c = 0.50$ $t_r = 0.33$ $Z = 1.09$ $F = 0.74$

BEVERTON AND HOLT
Estimation of Yield per Recruit (Y/R)

Y/R = 18.686332920 g Y = 209 861 kg

Ratio of Exploitation E = 0.68

Catch/Yield = 155 170 kg/209 861 kg = 73.94%

Table 1a

Stock Assessment for the year 1989 (November 1988-October 1989) for the species Mullus surmuletus

TRAWL FISHERY

Annual length distribution

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Numbers	1	9	25	26	14	17	6	5	1	1	1	1	0	0	0	0	0	0	103

Mean Length: 11.22 ± 0.19

Conversion of length distribution into weight

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Weight g	9.00	33.00	250.00	351.00	246.40	399.50	171.60	177.00	43.50	55.80	68.20	80.00	0.00	0.00	0.00	0.00	0.00	0.00	1,881.00

Conversion of total catch into numbers — Total catch 12,700Kg

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Numbers	6,752	33,759	168,793	175,545	94,524	114,779	40,910	33,759	6,752	6,752	6,752	6,752	0	0	0	0	0	0	695,429

INSHORE FISHERY

Annual length distribution

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Numbers	0	0	4	123	684	2,188	2,727	2,031	1,232	553	233	151	63	26	14	12	6	1	10,048

Mean Length: 13.97 ± 0.02

Conversion of length distribution into weight

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Weight g	0.00	0.00	40.00	1,660.50	12,038.40	51,418.00	77,992.20	71,897.40	53,552.00	30,857.40	15,896.60	12,080.00	6,533.10	2,990.00	1,750.00	1,704.00	1,011.00	197.00	341,651.60

Conversion of total catch into numbers — Total catch 142,470Kg

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Numbers	0	0	1,668	51,291	285,230	912,403	1,137,168	846,934	913,748	230,603	97,162	62,967	26,271	10,842	5,838	5,004	2,502	417	4,190,049

TRAWL AND INSHORE FISHERY

Total number of fish — Total catch 155,170Kg

Length cm	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Numbers	6,752	33,759	170,461	226,836	379,754	1,027,182	1,177,678	880,693	520,500	237,355	103,914	69,719	26,271	10,842	5,838	5,004	2,502	417	4,885,477

Table 2

Age cohort analysis for the species Mullus barbatus in 1989

Age groups	Numbers caught C_t	Numbers attaining each age N_t	$S_t = e^{Z_t}$	Z_t	F_t	Average numbers in sea	Weight Kg
0	428 693	8 689 421	0.72	0.33	0.06	7 365 609	51 559
1	780 402	6 258 770	0.65	0.42	0.15	5 149 530	77 758
2	2 290 755	4 095 967	0.27	1.29	1.02	2 302 836	61 025
3	632 152	1 125 308	0.27	1.30	1.03	629 686	30 981
4	251 119	306 716	0.05	3.04	2.77	96 047	7 559
5 and older	7 367	14 734			0.27 *		
	4 390 488	20 490 916		1.28	1.01	15 543 708	228 882

Parameters

$M = 0.27$ $e^{m/2} = 1.144537$
$K = 0.270$ $t_o = -1.20$ $L^{\infty} = 25.0$ cm $W^{\infty} = 166$ kg
$t_c = 0.50$ $t_r = 0.33$ $Z = 1.28$ $F = 1.01$

BEVERTON AND HOLT
Estimation of Yield per Recruit (Y/R)

Y/R = 15.320226810 g Y = 133 124 kg
Ratio of Exploitation E = 0.79
Catch/Yield = 118 210 kg/133 124 kg = 88.80%

Table 3

Age cohort analysis for the species Spicara smaris in 1989

Age groups	Numbers caught C_t	Numbers attaining each age N_t	$S_t = e^{Z_t}$	Z_t	F_t	Average numbers in sea	Weight Kg
0	361 454	52 645 250	0.73	0.31	0.008	45 018 697	189 079
1	7 682 479	38 689 454	0.57	0.56	0.26	29 714 238	356 571
2	12 356 009	22 049 481	0.26	1.35	1.05	12 110 918	286 423
3 and older	2 849 871	5 699 742			0.30 *		
	23 249 813	119 083 927		0.74	0.44	86 843 853	832 073

Parameters

$M = 0.30$ $e^{m/2} = 1.161834$
$K = 0.240$ $t_o = -1.00$ $L^{\infty} = 22.2$ cm $W^{\infty} = 100$ g
$t_c = 0.50$ $t_r = 0.33$ $Z = 0.74$ $F = 0.44$

BEVERTON AND HOLT
Estimation of Yield per Recruit (Y/R)

Y/R = 7.523681526 g Y = 396 086 kg
Ratio of Exploitation E = 0.59
Catch/Yield = 406 150 kg/396 086 kg = 102.54%

Table 4

Age cohort analysis for the species Boops boops in 1989

Age groups	Numbers caught C_t	Numbers attaining each age N_t	$S_t = e^{Z_t}$	Z_t	F_t	Average numbers in sea	Weight Kg
0	1 744	13 185 292	0.78	0.25	0.00	11 672 460	105 052
1	382 155	10 267 177	0.75	0.29	0.04	8 994 283	182 584
2	2 329 857	7 658 835	0.51	1.67	0.42	5 597 343	170 719
3	2 285 358	3 008 615	0.26	1.34	1.09	2 150 301	124 717
4	807 070	1 027 211	0.08	2.46	2.21	381 892	30 016
5 and older	43 878	87 756			0.25 *		
	5 850 062	36 134 886		1.00	0.75	28 796 279	613 088

Parameters

$M = 0.25$
$K = 0.530$
$t_c = 0.50$

$e^{m/2} = 1.133148$
$t_o = -0.45$
$t_r = 0.33$

$L^{\infty} = 24.0$ cm
$Z = 1.00$

$W^{\infty} = 140$ g
$F = 0.75$

BEVERTON AND HOLT
Estimation of Yield per Recruit (Y/R)

Y/R = 26.328915530 g Y = 347 154 kg
Ratio of Exploitation E = 0.75
Catch/Yield = 264 090 kg/347 154 kg = 76.07%

Table 5

Age cohort analysis for the species Pagellus erythrinus in 1989

Age groups	Numbers caught C_t	Numbers attaining each age N_t	$S_t = e^{Z_t}$	Z_t	F_t	Average numbers in sea	Weight Kg
0	13 004	957 439	0.58	0.55	0.02	734 295	6 609
1	16 164	553 577	0.57	0.57	0.04	421 298	8 426
2	111 354	313 437	0.32	1.15	0.62	186 416	11 726
3	48 297	99 059	0.21	1.54	1.01	50 523	4 219
4	15 041	21 253	0.05	3.09	2.56	6 564	763
5 and older	485	970			0.53 *		
	204 345	1 945 735		1.38	0.85	1 399 096	31 743

Parameters

$M = 0.53$ $e^{m/2} = 1.303431$
$K = 0.203$ $t_o = -0.62$ $L^{\infty} = 30.0$ cm $W^{\infty} = 342$ g
$t_c = 0.50$ $t_r = 0.33$ $Z = 1.38$ $F = 0.85$

BEVERTON AND HOLT
Estimation of Yield per Recruit (Y/R)

Y/R = 7.100518439 g Y = 6 798 kg
Ratio of Exploitation E = 0.62
Catch/Yield = 12 800 kg/6 798 kg = 188.29%

Table 6

Yield per recruit values and fishing mortality of the five species for the period 1986-1989

Parameter and year / Species	Yield per recruit (g)				Fishing mortality (F)			
	1986	1987	1988	1989	1986	1987	1988	1989
Mullus surmuletus	18.53	18.70	18.34	18.69	0.47	0.57	1.08	0.74
Mullus barbatus	13.62	15.72	13.01	15.32	0.76	0.93	1.65	1.01
Spicara smaris	6.99	7.50	7.67	7.52	0.62	0.46	0.36	0.44
Boops boops	25.0	27.84	28.90	26.33	0.88	0.60	0.47	0.75
Pagellus erythrinus	7.71	6.12	9.30	7.10	0.57	1.30	0.48	0.85

Table 7

Total mortality and ratio of exploitation for five species for the period 1986-1989

Parameter and year / Species	Total mortality (Z)				Ratio of exploitation (E)			
	1986	1987	1988	1989	1986	1987	1988	1989
Mullus surmuletus	0.82	0.92	1.43	1.09	0.57	0.62	0.75	0.68
Mullus barbatus	1.03	1.20	1.92	1.28	0.74	0.77	0.86	0.79
Spicara smaris	0.92	0.76	0.66	0.74	0.67	0.60	0.54	0.59
Boops boops	1.13	0.85	0.72	1.00	0.78	0.70	0.65	0.75
Pagellus erythrinus	1.10	1.83	1.01	1.38	0.52	1.71	0.47	0.62

Table 8

The stock, the yield and the total catch of the five species
for the period 1986-1989

Parameter and year / Species	Fish stock (kg) *				Yield (kg) **				Total catch (kg)			
	1986	1987	1988	1989	1986	1987	1988	1989	1986	1987	1988	1989
Mullus surmuletus	320 344	253 692	307 683	306 569	193 556	158 202	197 317	209 861	141 352	117 820	140 290	155 170
Mullus barbatus	234 800	194 105	251 553	228 882	169 547	147 687	171 748	133 124	128 344	111 524	153 440	118 210
Spicara smaris	618 383	1 046 829	1 084 960	832 073	317 425	503 142	521 730	396 086	308 189	536 114	500 730	406 150
Boops boops	613 784	826 452	784 992	613 088	329 981	573 762	517 889	347 154	265 882	367 066	321 560	264 090
Pagellus erythrinus	-	23 424	38 400	31 743	24 534	10 962	11 247	6 798	23 906	17 150	14 840	12 800

* At the beginning of the fishing season, i.e., 31 October each year

** Trawl and inshore

ANNEX 2

GEOGRAPHIC VARIATIONS IN BILOGICAL PARAMETERS OF RED BANDFISH, *Cepola macrophthalma*, IN THE WESTERN AEGEAN SEA: IMPLICATIONS FOR FISHERIES MANAGEMENT IN THE EASTERN MEDITERRANEAN

by

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The red bandfish, *Cepola macrophthalma* (Linnaeus, 1758) (= *Cepola rubescens* Linnaeus, 1766), is a benthic species found singly or in small groups at depths ranging from 10-20 m to 450 m (mainly from 70-200 m); in the eastern Atlantic it occurs from the British Isles to north of Senegal (Fischer *et al.*, 1987). It also appears throughout the Mediterranean Sea but not in the Black Sea (Tortonese, 1986). Although common in Greek waters, it is of no commercial value (as opposed to other Mediterranean countries, e.g., Spain, Italy); it forms a small but significant component of the trawl catch that is discarded (Stergiou *et al.*, in press).

Stergiou *et al.* (in press) examined the age, growth and mortality of red bandfish using the otoliths from 1 113 fish; samples were collected by a professional trawler, in the Euboikos and Pagassitikos Gulfs (Greece; Figure 1). Sampling took place in 1986-1988 over a grid of 34 stations (Figure 1) at depths ranging from 22 to 222 m. Stergiou *et al.* (in press) found that the red bandfish in the area south of Euripos strait is characterized by lower t_{max}, lower L_{max}, statistically significant smaller length-at-ages for ages >2yr, higher K, lower L_{∞} and W_{∞}; higher mortality (total, natural), and lower condition than is red bandfish in the area north of Euripos strait (Table 1). In addition, L_m50, population density and biomass were also higher in the northern area (Stergiou, 1991).

Stergiou *et al.* (in press) concluded that the variations in population parameters of red bandfish represent epigenetic responses to the different conditions (temperature and food) prevailing in the two regions. The August sea temperature in the southern area (at 40-50 m depth) is 2-3°C higher than in the northern area (see Stergiou, 1991; Stergiou *et al.*, in press) and nutrient (PO_4, NO_3, SiO_4) levels are from 2 to 10 times higher in the northern than southern area (Friligos, 1987). Stergiou *et al.* (in press) maintained that the quantity of food available to red bandfish (which feeds exclusively on zooplankton) in the southern area is lower than that in the northern area and is insufficient for growth beyond about 425 mm TL ($=L_{\infty}$). Hence, southern red bandfish must either migrate or die. Although there is no information available concerning the migratory habits of red bandfish, its elongated body shape (horizontal dimension 16 times the vertical one: Stergiou unpubl. data), its slow, wavy motion, its solitary nature and its vulnerability to whole-fish swallowers (Stergiou and Fourtouni, 1991) probably imply that red bandfish does not undertake long-run migrations.

Table I

Biological parameters of red bandfish in the areas north and south of Euripos strait (NES and SES respectively); BL5 = mean weighted back-calculated total length at age 5 (from Stergiou et al., in press)

Area	Biological parameters									
	tmax	Lmax	BL5	K	L_∞	W_∞	M	Z	E	to
	yr	mm	mm		mm	g				
NES	8	587	359	0.214	676.1	90.9	0.53	0.85	0.40	0.0007
SES	5	513	452	0.379	424.8	25.1	0.85	1.05	0.19	-0.0992

All differences observed in population parameters indicate (sensu Adams, 1980) that the northern stocks of red bandfish is towards the K-endpoint of the r-k continuum of life history strategies life history strategies (Pianka, 1970; Stearns, 1976). The opposite seems to be true of southern stocks of red bandfish. Although r- and k-selection assumes genetic divergence, intraspecific differences in life history parameters may also be an expression of developmental plasticity in response to proximate environmental parameters (e.g., fish: Shepherd and Grimes, 1983; rabbits: Williams and Moore, 1989). In fact, genetic and phenotypic explanations are not mutually exclusive (e.g., Lam and Calow, 1989; Williams and Moore, 1989; see also Bruton, 1990; Balon, 1983).

These marked intraspecific life history variations, whether phenotypic (and) or genetic, may have important implications for fisheries management. The eastern Mediterranean Sea is one of the most oligotrophic marine areas of the world (e.g., Friligos, 1980). Within this oligotrophic region relative eutrophic areas exist locally in gulfs, usually close to the proximity of large cities (e.g., Athens: Saronikos Gulf; Thessaloniki: Thermaikos Gulf), and along the northern/western rim of the Aegean sea (because of euthrophication, river discharge, extended continental shelf, presence of the Black Sea water mass). It is worthy of mention here that Saronikos Gulf and the northern/western rim of the Aegean Sea make up 64% of the total Greek marine catch (Stergiou, 1989). For a given species, population parameters such as K, L_∞, tc_{50}, t_{max}, Lm50, M, on which many fishery models are based, are expected to vary with the degree of eutrophication and, hence, management strategies should vary accordingly. Theoretically, species with r-characteristics may be fished at younger ages and at higher levels of fishing mortality and recover from overfishing more quickly than species with K-characteristics (Adams, 1980). This is clearly illustrated by the Beverton and Holt yield-per-recruit analysis of red bandfish in the two areas (Figure 2). The Beverton and Holt yield-per-recruit model, as modified by Gulland (see Sparre et al., 1989), estimates the yield that can be harvested from the growth of a cohort. The biological parameters of the model are:

M, the natural mortality
W_{∞}, the mean asymptotic weight
K, the growth parameter
t_o, the age at which length $= 0$
t_c, the age at first capture
t_r, the age at recruitment
F, the fishing mortality

and Y/R is related to the above mentioned parameters as follows:
$Y/R=Fe[-M(tc-tr)]W_{\infty}[(1/Z)-(3S/(Z+K))+(3S^2/(Z+2K))-((S^3)/(Z+3K))]$

where $S=e[-K(tc-to)]$

The yield-per-recruit analysis shows that there are differences in the fisheries of red bandfish in the two areas. $(Y/R)_{max}$ in the northern area is almost twice that in the southern area (Figure 2). In the northern area, $(Y/R)_{max}$, for a constant $t_c=1.8$ (which is a function of gear selectivity), occurs at a lower level of fishing mortality (Figure 2a) and, for a constant $F=0.5$, at a higher age at first capture (Figure 2b); the northern red bandfish is more sensitive to overfishing in terms of fishing mortality (Figure 2a). This may explain the lower exploitation rate of red bandfish in the southern area (Table 1).

To sum up, population dynamic parameters of (at least) benthic and demersal fish that do not undergo long-run migrations must be examined in relation to the physical/chemical phenomena prevailing in a given region. Such phenomena may include currents (e.g., Black sea outflow), fronts (e.g., Limnos front), etesian winds (Stergiou, in press), upwelling (e.g., Korinthiakos Gulf), possible island mass effects (e.g., Cyclades isles), man-made eutrophication (e.g., Friligos, 1987). This may be essential for the fisheries ecology and management in the eastern Mediterranean, a highly oligotrophic environment where spatial variations in production potential, because of physical and/or anthropogenic effects, may be more critical in comparison with other relatively eutrophic marine regions (e.g., North Sea, Northeast Atlantic). From the ecological point of view, this may cast light on the mechanisms involved in the control of fish population dynamics. From the managerial point of view, population parameters and resulting fishery management schemes in the eastern Mediterranean may be confounded by the mixing of different populations of a fish species [the situation becomes more complicated when considering the multispecies nature of the Mediterranean trawl fishery]. However, from the practical viewpoint it may not be feasible to apply different management schemes on such a small spatial scale.

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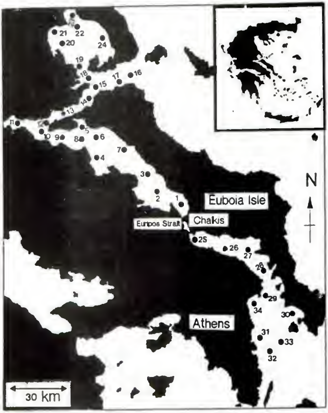
LIST OF FIGURES

Figure 1. Map showing location of sampling stations. North of Euripos strait: stations 1 to 24. South of Euripos strait: stations 25 to 34

Figure 2. The effect of (a) different levels of fishing mortality with constant age at first capture $t_c = 1.8$ yr (estimated from length-converted catch curve: Stergiou, 1991) and (b) different ages at first capture at constant fishing mortality $F = 0.50$, on yield per recruit of red bandfish in the areas north and south of Euripos strait. In both cases was assumed to be $t_r = 0.4$ yr



Region I = stations 1 to 24
Region II = stations 25 to 34

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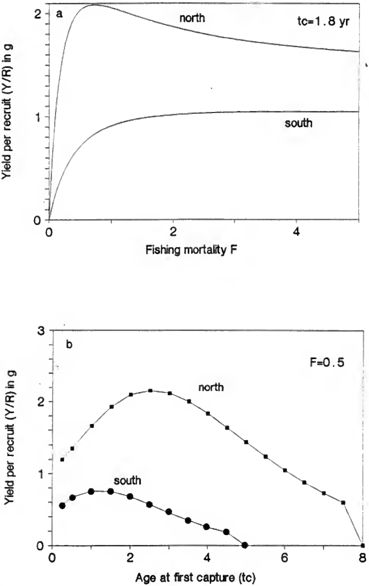

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ANNEX 3

THE SWORDFISH FISHERY IN THE AEGEAN SEA; ANALYSIS OF SIZE DATA COLLECTED FROM 1986-1990

by

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INTRODUCTION

Although fishing for swordfish is a relatively new activity in Greece, it is estimated that some 360 boats operating from 70 ports were already involved in the fishery in 1989 and a total production of 1 700 was reported in that year (Anonymous, 1990). Even though the 1989 production might have been overestimated by 10-20%, records for the last five years show that Greece is one of the most important producers in the Mediterranean (Anonymous, 1991).

Fishing is carried out using drifting longlines throughout most of the Aegean Sea, off the west coast of Greece in the Ionian Sea, and occasionally eastward toward Cyprus. The peak of the fishing season is from May to September; since 1988 a closed season has been implemented from 1 October to 31 January.

The two main fishing fleets for swordfish in Greece are based in Kalymnos, in the southeastern Aegean Sea and in Chania on the island of Crete. The two fleets use identical methods but operate in different areas (Figure 1). Together, they account for more than 50% of the total annual Greek production and almost 80% of the production in the Aegean Sea.

The present work aims to analyse size data taken from animals landed at the above-mentioned ports during the last five years and to identify, if possible, trends of the swordfish fishery in the area.

MATERIALS AND METHODS

Measurements of lower jaw fork length (LJFL) were taken to the nearest centimetre for 4 610 animals landed at the ports of Kalymnos and Chania from June to September of the years 1986, 1987, 1988 and 1990 (Table 1).

All individuals were aged according to the von Bertalanffy growth equation, using the following parameters $L_{\infty} = 218.93$, $k = 0.25$ and $t_o = -1.54$. These estimates were derived from data presented in an earlier work (Tsimenides and Tserpes, in preparation) combined with subsequently collected data.

Table 1

Composition of the total sample according to the timing and place of landing

YEAR	KALYMNOS	CHANIA
1986	566	312
1987	754	322
1988	783	533
1990	531	809
Total	2 634	1 976

A chi-square test of significance followed by partitioning of the degrees of freedom (Siegel and Castellan, 1989) was applied separately for data from each port to identify possible annual differences in the frequency distributions of the aged animals.

The total mortality rate Z was calculated for each annual sampling using the formula Z = k*(Loo-L)/(L-L') (Beverton and Holt, 1956 where L' is a length at and after which the fish are under full exploitation and L is the mean length of all fish of length L' and longer.

Z was also calculated by means of length converted catch curve analysis (Sickle, 1977) in the modified form used for aged samples (Pauly, 1983; cited in Jones, 1984). In the analysis the first length group used was always considered the group having the highest frequency in the given sample; i.e., L' coincided with the beginning of the first group used. Usually length groups greater than 190-200 cm were excluded from the analysis since very few animals were included in those groups.

All mortality estimates were carried out using the LFSA computer package (Sparre, 1987).

RESULTS

Figure 2 shows the percentage length frequency distribution of the sampled animals while the corresponding age distribution is shown in Figure 3.

The Chi-square test revealed that the differences between the annual age distributions were highly significant in data from both ports (P((0.001; chi-square = 465.99 and 211.53 in Kalymnos and Chania correspondingly with 15 degrees of freedom). However, partitioning of the degrees of freedom showed that the differences were mainly due to the variations observed between age groups O and I, and that the differences between the other groups were in many cases insignificant at the 95% confidence level.

Table 2 shows the estimates of Z obtained by the two applied methods.

Table 2

Estimates of Z obtained from the Beverton and Holt equation (BH) and by means of catch curve analysis (CCA) (L' indicated the length at and after which the fish were considered to be under full exploitation)

YEAR	KALYMNOS			CHANIA		
	BH	CCA	L'	BH	CCA	L'
1986	0.73	0.68	120	0.68	0.57	120
1987	0.60	0.63	130	0.50	0.48	90
1988	0.65	0.64	100	0.71	0.63	80
1990	0.61	0.61	100	1.22	0.75	100

DISCUSSION

Collected data indicate that fishing is mainly oriented towards age groups O and 1, especially in the area fished by the Chania fleet. Figure 3 shows that these groups account, in all cases except in Kalymnos (1987) for more than 50% of the total annual catch and in some cases such as in Chania in 1988 and 1990 for about 80% of the catch.

Undoubtedly the above estimates depend on the growth parameters employed, but there is not much disagreement in the literature considering growth rate of juvenile swordfish (Berkeley and Houde, 1983; Megalofonou et al., 1990; Tsimenides and Tserpes, 1989). Although there are discrepancies considering length at age for older animals it seems that even if different growth parameters were used the results obtained would not be affected dramatically concerning the contribution of juveniles to the total catch.

Annual length distributions show a much more stable pattern in Kalymnos than in Chania (Figure 2). However, the chi-square test revealed that the age distribution patterns resemble each other in many cases when variations between the first two age groups have been eliminated.

Since the catch in Chania is virtually all composed of animals of 0 and 1 age groups, it is possible that annual fluctuations in recruitment are mainly responsible for the different length patterns observed. This may also explain the wider range of mortality rates estimated in Chania (Table 2).

In general, the area fished by the Chania fleet seems to be a nursery ground for juvenile swordfish. The closed season operating during the winter months, together with a successful recruitment in 1989, may explain the extremely high number of one year old individuals caught in summer 1990 (Figures 2 and 3). However, further observations are needed to evaluate the consequences of the closed season established in 1988.

The situation in Kalymnos seems to be more stable. Mortality rates do not differ much, and although the fishery is again based on juveniles, it is not so dependant on 0 and 1 age groups.

Much longer time-series data are needed to evaluate the situation of the swordfish fishery in the area. The results here are based on data collected only during the summer months and although these months correspond to the peak of the fishing season the situation could appear different if complete annual data were available.

Moreover, for such a migratory species, a long series of data from different Mediterranean areas should be combined and analysed to obtain reliable estimates for the stock parameters.

Unfortunately, detailed data on the swordfish fishery in the Mediterranean exist only for the last five years; however, stock assessment studies conducted for the Atlantic by the ICAAT demonstrated that the juvenile swordfish stock size has shown a general increasing trend from 1978 to the present while there is a consistent decreasing trend in stock size of adults (Anonymous, 1991). The same author also states that it is unlikely that recruitment will continue to increase. Usually recruitment in pelagic fish stocks tends to show rising or falling trends (Cushing, 1981).

Although Greek catches do not show a decreasing trend and the fishermen claim that large fish are becoming very rare, the data obtained here are not adequate to show if the situation in the Mediterranean is as described in the Atlantic.

Di Natale (1990) described the swordfish fishery in the Tyrrhenian Sea, Italy, from 1985 until 1989, and although he states that the annual length distribution of the samples collected shows a confused pattern, he considers that juvenile swordfish stock size is showing an increasing trend throughout the Mediterranean basin. He also suggests that a reduction of the fishing effort seems to be necessary for the maintenance of the stock.

However, there is no information about the mixing of the different stocks and it is not yet known if a separate Mediterranean swordfish stock exists although it seems that recent studies support this hypothesis (Y. Kotulas, University of Crete, Genetics Laboratory, personal communication).

Unquestionably there is evidence of growth overfishing which could result in recruitment overfishing and a collapse of the swordfish fishery in the future. Since swordfish is a highly migratory species, international agreements are needed to solve this problem and for the successful management of this valuable resource.

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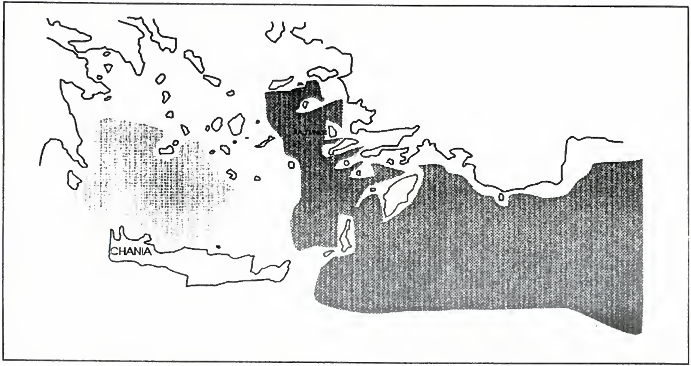

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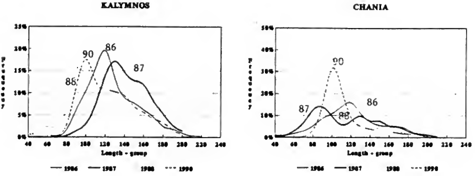

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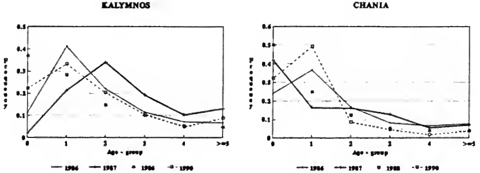

Figure 3. Age frequency distributions of the sampled animals

ANNEX 4

AGE, GROWTH AND STATE OF STOCK OF RED MULLET (Mullus barbatus L ., 1758) in the Saronikos Gulf of Greece

by

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INTRODUCTION

Red mullet (Mullus barbatus L., 1758) is an important demersal species in Greek seas attracting much fishing effort because of its high commercial value. In a previous study carried out at this laboratory (Karlou and Vrantzas, 1989) an attempt was made to examine the state of the stock of red mullet in the Saronikos Gulf by the relative yield-per-recruit approach using length composition data from trawl surveys. It was then recognized that more reliable estimates of growth and mortality parameters were needed in order to draw valid conclusions.

In the present study a method of reading the age of red mullet is described and validated, and then the state of the stock of red mullet in the Saronikos Gulf is examined using age data.

MATERIALS AND METHODS

In the Saronikos Gulf red mullet is fished primarily by trawlers and seiners (beach-seiners), which are allowed to operate from October to May. Their cod-ends have mesh sizes of 14 mm (knot to knot) and 8 mm respectively. Limited amounts are caught by other gears mainly gillnets, which operate throughout the year.

The samples of red mullet for the present study were obtained mainly in the fishing port of Piraeus from the catches of trawlers fishing in the Saronikos Gulf during the fishing months (January-May and October-December) of the years 1989 and 1990. Samples were taken randomly from one to four vessels at intervals of about two months. Supplementary samples were obtained during the period closed to fishing (June-September) by a chartered seiner in August and September of 1989 and one sample from a gillnet in July 1991.

The total length of the fish was measured to the nearest half centimetre above. The numbers at length were raised to the total catch of the vessels sampled to give a length frequency distribution, which is taken to represent the length distribution of red mullet at the respective sampling time. Five fish from each 0.5 cm length class throughout the available range were retained for examination of gonadal maturity and age determination.

The stage of gonadal maturity was expressed by the scale of Nikolsky (1963). Age was determined from checking sagittal otoliths. Both otoliths were extracted and after washing in warm water and ethanol baths were dried by blotting paper and stored in glycerine or kept dry in plastic vials. The storage of otoliths in glycerine improves their appearance for age-reading, but when it is prolonged beyond three or four months, otoliths become translucent and lose structural details. The same type of deterioration was seen within much shorter times when ethanol or water were used as storage media.

For age-reading otoliths were immersed in ethanol in a black plastic dish and examined under reflected light with a binocular microscope (WILD M3) fitted with a semi-automatic distance micrometer. The checks counted as annual were hyaline rings distinguished from false rings on the basis of their morphology and location.

The ages and lengths of the fish retained at each sampling time formed an age-length key common for both sexes. This key was used to derive the age frequency distribution and the mean length at age of red mullet at the respective sampling time. Age was expressed in years assuming an arbitrary birthday on 1 January. The growth parameter values were derived from the age-at-length data of all sampling times. For this purpose age was expressed in months setting the beginning in June (time of maximum spawning). An ordinary von Bertalanffy growth equation was fitted to these data and its parameters Linf (length infinite), K (curvature coefficient) and t_o (time of zero length) were estimated by a non-linear regression procedure in a computer using software provided by FAO (Sparre, 1987).

An estimate of the total mortality coefficient (Z) was obtained for the whole period of study from the sum of the seasonal relative age frequency distributions (percentage numbers at age) determined from the samples taken from trawlers. The estimation of Z was made by regression analysis through the points fitting to the equation:

$$1n(N_t) = 1n(N_o) - Zt$$

where t is the age in years, N_t the number at age t and $1n(N_o)$ the Y axis intercept.

A working value of the natural mortality coefficient (M) was obtained from the equation of Pauly (1980) inserting 16°C for the water temperature and the estimated values of Linf and K.

The value of length at first capture (Lc50%) was taken to be equal to that estimated previously (Karlou and Vrantzas, 1989) from length frequency data.

For evaluation of the state of the stock and the model of relative yield per recruit (Beverton and Holt, 1964) was applied in an approach similar to that reported previously (Karlou and Vrantzas, 1989). It was assumed that apart from the value of M all other parameter values were acceptable estimates, and then the effect of fishing on the yield was explored for a range of likely M values. In assessing the relative position of the current exploitation rate (Ecurr = E/Z, where Ecurr is the current exploitation rate and F the fishing mortality coefficient), the concept of "best exploitation rate" (E_o.1) suggested by Pauly (1986) was applied instead of the theoretical exploitation rate for maximum yield (Emax).

RESULTS AND DISCUSSION

Figure 1 shows the length frequency distributions of red mullet at the sampling times during the study period. It is seen that small fish appear in great numbers at first in August. At this time the length distribution shows a distinct mode in the smaller sizes with modal length of about 7.5 cm and a range from 4.5 to 12 cm. In September no separation of modes is apparent while the small sizes have increased. Distinction of modes is also difficult in the months after October.

All fish in August with lengths corresponding to the first mode and those caught in September with lengths up to 13 cm could be easily recognized as "juveniles" by their distinct coloration and appearance. This appearance is gradually lost from small fish in later months.

The examination of gonadal maturity within a year (Figure 2) indicates that peak spawning of red mullet occurs from May to July.

It is noted that the gonads of all fish with "juvenile" appearance were in stage I of the maturity scale, i.e., they had not entered the maturation cycle while the small fish caught in spring (with lengths around 10 cm) were in advanced stages of gonadal maturity. The fact that recruitment of the small immature fish with "juvenile" appearance occurs shortly after peak spawning suggests that they are young of the year. This conclusion is supported by information from fishermen which indicates that red mullets in pelagic form are present only in summer and they begin to settle to the bottom in large numbers in July. Findings of Gottlieb (1956) on the coast of Israel corroborate the above information.

It is also noted that in a preliminary investigation it was found that from October (when the authors started to take samples from trawlers) until May the proportions and size ranges of small red mullets in the catches of seiners approximate those in the catches of trawlers (unpublished data). Furthermore, no discard of small red mullets occurs at any time. Therefore the use of a different sampling gear from October to May does not affect the selection of small sizes from the fishable population and the samples represent the population equally well at all times apart from the gillnet sample.

In establishing the age reading system the authors were guided by the structure of the otoliths of "juveniles" and then followed its development in the otoliths of the bulk of the small fish throughout the autumn and later months. Figure 3 shows otoliths of red mullet of different ages. Otoliths of small fish in summer and early autumn have a characteristic opaque form apart from a hyaline spot near the centre (Figure 3a). In many of them two early hyaline rings were visible in positions corresponding to back-calculated lengths of fish of about 4-5 cm and 7.5-10 cm respectively. As size increases this central opaque area is surrounded by successive narrow hyaline rings forming a broad zone of lower density (Figure 3b). The first annual ring is typically located a little beyond the end of this zone after an opaque band of varying width and density (Figures 3c and 3d). Other annual rings follow at distances decreasing with age.

In some otoliths the hyaline rings were invisible or so irregularly spaced that age-reading was not possible. Generally about 85 percent of otoliths were readable.

The formation of the first annual ring starts in winter (December-January) and ends in late spring or early summer. Some otoliths had already completed the first annual ring by March and had opaque edges. Confirmation that this ring is annual comes from measurements of the marginal widths beyond the first annual ring (Figure 4). These show that within a year there is one continuous decrease of marginal width from January to July. Other annual rings are also formed in about the same period. Almost all otoliths with at least one annual ring had opaque edges from July to October.

The data of mean length at age for each sampling time presented graphically in Figure 5 appear to fit to a von Bertalanffy growth curve. The values of growth parameters estimated from these data are: Linf = 23.5 cm, K = 0.51 per year and t_o = -0.86 years.

Present estimates of length for a given age are generally higher than those reported by previous workers for the red mullet of various Mediterranean areas (Table 1); they are close only to estimates for the older ages of red mullet of Tunisia (Gharbi and Ktari, 1981) and south France (Bourgis, 1952). It is noted that considerable differences exist also among the previous estimates. At present not all these differences can be explained. However, at least some of the previous workers appear to have overestimated the age of red mullet because they counted false pre-annual rings as annual.

In estimating the total mortality coefficient for use in the relative yield-per-recruit model it was assumed that the overall pattern of exploitation is determined by trawlers. The age frequency distribution in the catches of trawlers during the period of study is given in Table 2. The mean total mortality value for the whole period derived from these data is Z = 1.88 (r = 0.99).

The value of natural mortality obtained from the Pauly equation is M = 0.94. It is recognized that this estimate is only a rough approximation and in some cases may be two times higher or lower than the actual value (Sparre et al., 1989). On this basis a working lower limit of M at 0.5 may be set. On the other hand, considering that red mullet is fished intensively in the Saronikos Gulf it may be taken that half of the total mortality is due to fishing and an upper limit set for M at 0.95.

The results of exploring the expected relative position of current exploitation rates with varying the values of M within the above set limits are given in Table 3. These indicate overfishing or a situation close to it for some of the likely values of M. Although the exact state of the stocks cannot be deduced from these results, it is concluded that the most rational management policy at present would be to prevent an increase of current fishing levels.

ACKNOWLEDGEMENTS

This work owes much to the dedication and skilled technical assistance of colleagues Antonis Argyrokastritis and Angeliki Adamidou to whom the authors express their sincere thanks.

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Table 1

Estimates of Length at Age of Red Mullet (male M; female F) of various Mediterranean Areas

Age Group	Saronikos Gulf Greece Present Work		Saronikos Gulf Papaconstantinou et al. 1981*		Coast of Tunisia Gharbi and Ktari 1981		South France Bougis 1952		Adriatic Haidar 1970		Egypt Hashem 1973		Cyprus Livadas 1989		Israel Gottlieb 1956	
	May M+F	Dec. M+F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
I	13.9	16.6	10.7	11.2	12.70	13.05	10.0	12.0	10.1	12.2	9.70	10.45	11.5	11.5	9.9	10.7
II	18.1	18.9	12.8	13.4	15.22	16.75	14.5	17.5	12.9	15.2	11.81	13.01	13.2	13.0	11.7	13.1
III	20.4	20.5	14.0	14.7	18.54	20.76	16.5	20.0	14.2	16.5	13.81	15.37	15.9	16.2	13.5	15.3
IV	21.4	21.5	15.2	15.9	20.58	23.15	17.5	21.2	15.1	17.5	15.58	17.52	17.5	18.9	15.5	17.4
V		23.2	16.1	17.1		24.59			15.7	18.3	17.13	19.50				19.5
VI			17.2	18.6												
VII				20.0												
VIII				20.5												

* Fork length converted to total using factors given by the authors

Table 2

Age Frequency distributions of Red Mullet Caught by Trawlers in Saronikos Gulf During the Fishing periods of the years 1989 and 1990

Age Group \ Sampling Time	1989						1990					
	Jan. %	Mar. %	May %	Oct. %	Dec. %	Total	Jan. %	May %	Oct. %	Dec. %	Total	Grand Total
0	-	-	-	68.60	90.00	158.60	-	-	64.79	74.14	138.93	297.5 *
I	84.50	87.10	86.70	23.60	6.70	288.60	94.80	91.02	28.18	16.70	230.70	519.3
II	12.70	11.25	12.94	7.15	2.35	46.10	4.50	6.57	6.40	6.05	23.52	69.6
III	2.80	1.48	0.37	0.67	0.75	6.05	0.62	1.84	0.44	2.15	5.03	11.08
IV	-	0.17	-	-	0.18	0.35	-	0.56	-	0.91	1.47	1.82
V	-	-	-	-	0.06	0.06	-	-	0.07	0.01	0.08	0.14 *

* Points not used in Regression for the Estimation of Z

Table 3

Exploration of the Relative Position of Ecurr. with Varying Values of M in the Case of Red Mullet of Saronikos Gulf

M	M/K	F	E current (F/Z	Max	E 0.1
0.95	1.90	0.93	0.50	0.85	0.75
0.75	1.50	1.13	0.60	0.75	0.70
0.60	1.20	1.28	0.68	0.75	0.65
0.50	1.00	1.38	0.73	0.70	0.60

Constant Input Values:

Linf = 23.5 cm
K = 0.51
Lc50% = 12.8 cm
Z = 1.88

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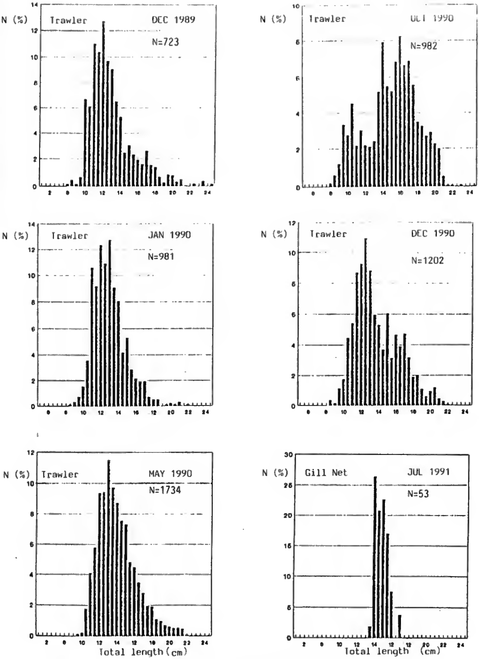


Figure 1. Length Frequency Distributions of Red Mullet in Saronikos Gulf

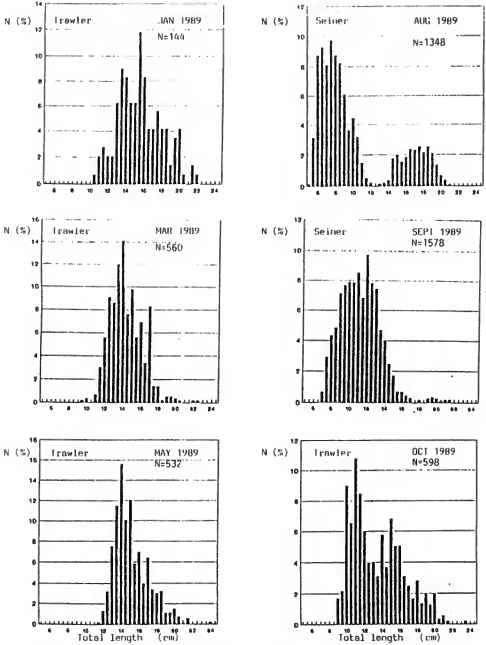


Figure 1. Length Frequency Distributions of Red Mullet in Saronikos Gulf (continued)

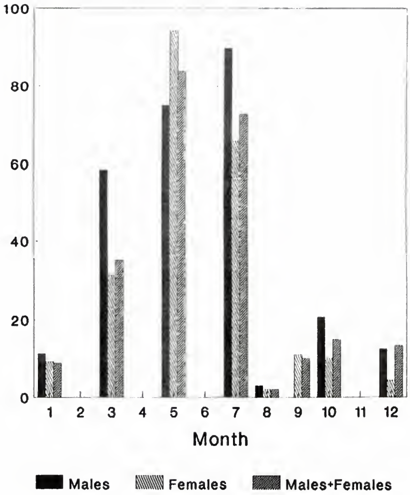


Figure 2. Percentages of Red Mullet in Gonadal Maturity Stages IV, V and VI within a Year (Fish in stage I were not considered)

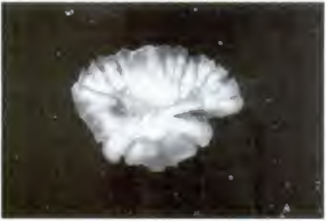


Figure 3a. Otolith of red mullet from a 10.2 cm juvenile caught in August (age O)

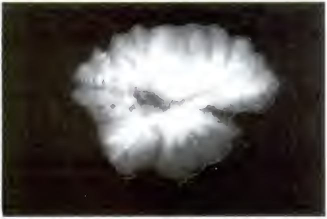


Figure 3b. Otolith of red mullet from a 15.0 cm female caught in September with no annual hyaline ring (age O) showing many false rings in the peripheral zone

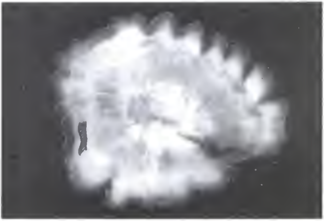


Figure 3c. Otolith of red mullet from a 19.4 cm female caught in September with two annual rings (age II)

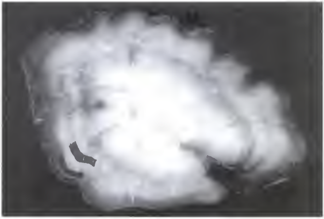
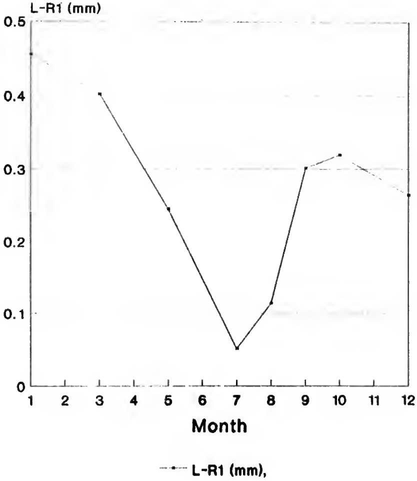


Figure 3d. Otolith of red mullet from a 22.9 cm female caught in January with three annual rings (age IV)



L = otolith diameter (mm)
R1 = 1st ring diameter (mm)

Figure 4. Marginal Widths Beyond the First Annual Ring

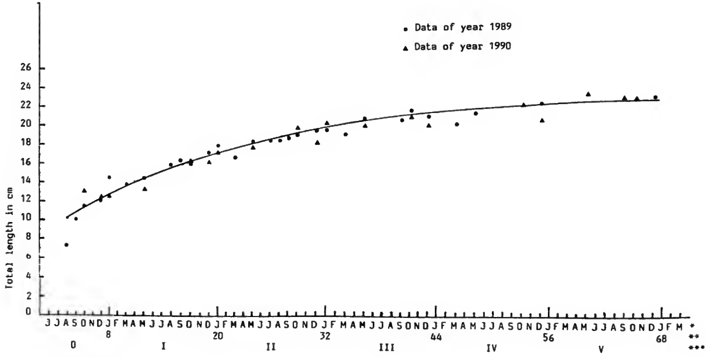


Figure 5. Mean length at age of Red Mullet in Saronikos Gulf (Years 1989 and 1990)

* Month
** Age in months
*** Age group

TEUTHOFAUNA OF THE NORTH AEGEAN SEA: PRELIMINARY RESULTS ON CATCH COMPOSITION AND DISTRIBUTION

by

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INTRODUCTION

In the Mediterranean Sea cephalopods were mostly exploited and studied in the western basin while in the eastern basins only some species are the subject of exploitation (Worms, 1983), and there are some areas, such as in the northern Aegean Sea, in which scientific knowledge of the whole class is rather limited. Available scientific literature, in fact, relates to the southern part (Barash and Danin, 1988) or to a few neighbouring marine districts of the Aegean Sea (Ruby and Knudsen, 1972); Kaspiris and Tsiambaos, 1984), 1986; Katagan and Kocatas, 1990). Therefore, in the present work, carried out in the context of the ongoing research programme "investigation of the abundance and distribution of demersal stock of primary importance to the Greek fishery in the North Aegean Sea" funded by the EEC, preliminary information relative to the catch, composition and distribution of the Teuthofauma, never before studied in this area, are reported. Aspects of the population structure of some species of economic interest are also presented.

MATERIALS AND METHODS

The geographical area investigated (Figure 1) is divided into sub-areas: one on the western side, bounded by the Sporades islands and very deep water, and the other a wider area, in the eastern part, neighbouring Limnos island. The samples were taken during four seasonal trawl surveys carried out respectively in June, August-September, November-December 1990 and February-March 1991. A commercial trawler of 115 tons GT equipped with 250 HP twin engines was chartered. The trawl net had a cod-end mesh of 16 mm between stretched knots.

The experimental design adopted was random-stratified. The area under investigation was divided into 3 depth strata: 0-100, 100-200, 200-500 m. However, in the first stratum the lowest depth investigated was 60 m in the West Aegean and 32 m in the East. The hauls, carried out from dawn to dusk, each lasted for 1 hour on average. There were 10 hauls in the Western area and 20 in the East per each survey.

The total catch of cephalopods was weighed on board and examined. There was a preliminary determination according to species, then a weighing and a count of individuals. For each specimen the following measurements were taken: dorsal mantle length, weight, sex and maturity stage of gonad. Average catch per unit effort (CPUE) (expressed in kg/h), with standard deviation, was estimated for each depth stratum and for all areas. It was regarded as an index of abundance of the whole class of cephalopods. Furthermore, the percentage of cephalopods relative to the total catch was calculated.

RESULTS

Catches

The CPUE values of cephalopods (presented in Table 1), with exceptions, exhibited a high variability, in both areas and all depth strata (average C.V. = 82.98% in the western area; average C.V. = 67.25 in the eastern one). Hourly yield fluctuation was higher with increased depth. However, during the four trawl surveys, catches without cephalopods were rather rare. Hourly catches came out slightly higher in the eastern side (on average 6.02 kg/h) than in the west (on average 4.30 kg/h) though high variability between hauls and the different numbers of hauls in the two areas until now prevented statistical testing. In the context of each area, the second depth zone (100-200 m) was most productive giving, on average, an hourly yield of 7.12 kg/h and 5.98 kg/h in the eastern and in the western areas respectively.

As regards the seasons in which the surveys were carried out, greatest hourly catches were observed in June near the Sporades (western area) and during November-December to the south of Limnos (eastern area). However, seasonal changes, shown in the hourly catches (compared, by means of t-test, only for the first depth stratum, in both areas, because at this depth the hourly yields were rather normally distributed), were not statistically significant. Moreover, though the greatest hourly catches were obtained in the eastern area, the percentage of cephalopods in the total catches was superior in the western one. Here, in fact, cephalopods made up, on average, 11.3% of total catch whereas in the east they represented, on average, 6.3% of the total catch.

Composition and distribution

Catch composition of cephalopods included 26 species, belonging to 7 families and 18 genera, as presented in Table 2. Hauls were not located between 200 and 300 m in the western area. The contribution of each species to the catch varied according to their geographical and bathymetrical distribution and in relation to the kind of habitat (pelagic or benthic). First, considering what was reported by Mangold and Boletzky (1987), the species Sepiola ligulata, Sepiola affinis, Neorossia caroli, Alloteuthis media, Abralia verany, Histioteuthis reversa, Eledone cirrhosa and Bathypolypus sponsalis are new for the North Aegean Sea while Sepiola lingulata, Sepiola affinis and Nerossia caroli are new also for the eastern Mediterranean; the presence of Rossia macrosoma, Octopus salutii and Pteroctopus tetracirrhus was considered rather uncertain in the investigated area.

Sepia officinalis and Octopus vulgaris, though species of primary economic importance and very widespread in the Mediterranean, were rarely caught and only in the first depth zone (0-100 m), because of their occurrence in shallow water or on different kinds of bottom than those trawled during the surveys. Similarly Loligo vulgaris, being a semipelagic species, is normally caught with other types of gear.

The species Sepia orbignyana, Sepia elegans, Illex coindetii and Eledone cirrhosa were frequently found in a wide bathymetric range in both areas. In particular, as shown in Table 3, Sepia orbignyana was mostly fished between 100 and 200 m while Sepia elegans appeared mainly in the first depth stratum (0-100 m), both in the west and east. For Illex coindetii too, no significant variations emerged in the bathymetrical distribution between the two areas where this species was especially caught between 100 and 300 m.

Eledone cirrhosa was mostly found at a depth less than 200 m but also on epibathyal bottoms. Eledone moschata, exhibited a typical coastal distribution and it was less common in the catch than the above-mentioned species. Alloteuthis media was exclusively found on the continental shelf (0-200 m). Octopus salutii showed a typical bathyal distribution, mostly in the eastern area. The sepiolid Sepietta oweniana presented a wide geographical and bathymetrical distribution. Other species such as Rossia macrosoma and Loligo forbesii occurred mostly on epibathyal bottoms, Pteroctopus tetracirrhus in the mesobathyal, Scaeurgus unicirrhus, in a wider depth range, were occasionally found in both areas. Neorossia caroli and Bathypolypus sponsalis were caught at the greatest depths investigated in the North Aegean. The remaining species, mostly nectopelagic, were rather randomly found.

Remarks on some stocks of economic interest

Some aspects relative to the structure of the most widespread stocks in the studied areas and with a commercial interest are reported. The species are considered in systematic order. There are no data relative to the western area during the survey carried out in June.

Sepia orbignyana (Pink cuttlefish)

This species is regularly exploited in the western Mediterranean even though there are no specific statistics. Pink cuttlefish were more abundant in the eastern area of the North Aegean than in the western, and constituted, on average, about 25% of the catch of cephalapods. The stock presented, in both areas and during each survey, a wide range between minimum and maximum lengths (on average 66 mm) due to the presence at least two (if not more) groups identifiable in the length frequency distribution (Figure 2). Small individuals (26-32 mm DML), new recruits, were found all year long and mostly during November-December in the second depth stratum (100-200 m) of the eastern area, which probably represents a nursery ground for this cuttlefish. These recruits had modal length of 44-50 mm after three months (February-March), showing a rate of growth of about 6 mm per month, based on reliable available information in Mangold-Wirz, 1963; Boletzky, 1988; Ragonese and Jereb, 1990). The largest mature specimens caught during later spring and summer were not found in the successive seasonal surveys, so the mean size of the stock was lower in autumn and winter. The highest percentage of mature individuals was observed in June (about 40%) and in August-September (about 35%). Only a small portion of females presented large and smooth eggs in November-December and February-March. Females and males were always found together and even though the relative prevalence of one sex over the other was variable, they showed the same distributional pattern, as observed by Jereb and Ragonese (1990) in the Sicilian Channel.

Sepia elegans (Elegant cuttlefish)

This small cuttlefish had a low mean contribution in weight (5%) to the total catch of cephalopods. The sampled population had always a wide range of sizes (on average 40 mm) and did not exhibit separate modal groups in the length frequency distribution (Figure 3). The highest number of recruits (individuals less than 30 mm DML) was caught during August-September in both areas. The analysis of mean length with depth did not show any particular trend: small and large specimens were fished together. The average size of the stock increased from the second to the third survey. The sex-ratio did not show any significant departure from 1:1. Mature specimens were mostly found during August-September and November-December (on average 20%).

Illex coindetii (Broadtail shortfin squid)

In the Mediterranean a sizeable portion of catches reported under the category "unidentified loliginids and ommastrephids" are attributable to this species (Roper et al., 1984). Illex coindetii represented, on average, 11% of the catch of cephalopods in the North Aegean Sea. Recruitment was observed from August-September to February-March in a wide bathymetrical range (100-400 m) (Figure 3). The recruits caught in summer showed a gradual growth throughout autumn until winter (Figure 4) while in the meantime new recruits reached fishing bottoms so that two or more groups were present in the stock during the third and fourth surveys.

The sex-ratio was in favour of males in the first two surveys (2:1) and during the third only in the eastern area (1.4:1) whereas in the western it was in favour of females (1:2). The sex-ratio was 1:1, in both areas, during February-March. The highest percentage of females with large eggs was found in June (about 18%) and November-December (about 30%). In June, the sampled population was mostly made up of large individuals, the number of which was reduced in August-September probably due to high post-spawning mortality (Mangold-Wirz, 1963; Roper et al., 1984).

Eledone cirrhosa (Horned octopus)

In the western basin of the Mediterranean there are extensive fisheries for this species which made up the greatest portion (on average about 45%) of cephalopods fished in the North Aegean Sea. Reproduction was mainly observed in August-September when the stock consisted of larger specimens (until 128 mm DML) with mature and spent gonads (west area bout 19%; east area about 10%) and very small individuals (from the spring spawning), which constituted the first modal component in the length distribution in both areas (Figure 5).

Gradual growth of the first group of individuals was observed. They were larger in the western than in the eastern side probably because there they had hatched earlier.

These individuals would reach, in February-March, the modal size of 56-62 mm in the western and 44-50 mm in the eastern area. The number of largest specimens fished in August-September was reduced in November-December and none was caught in February-March when the stock consisted only of new generations. A similar situation was observed in the Ligurian Sea by Relini and Orsi Relini (1984). In the first months of the year, the bathymetrical distribution of the stock tended towards the coast probably in anticipation of the reproductive period: in fact, a small percentage (4%) of mature specimens, mostly males, was caught at this time. The two sexes were usually found in equal numbers in the investigated areas though there was some "segregation" since females were more abundant than males at lower depths.

CONCLUSIONS

The role of cephalopods in the marine ecosystem is still little known and conventional fishing gear, such as trawl net, is not sufficient to monitor the whole class, which lives in a diversity of habitats, from pelagic to benthic. For example, in terms of both sampling design and the kind of gear used, information on stocks of Sepia officinalis, Octopus vulgaris and Loligo vulgaris was rather limited during these first four trawl surveys, confirming that the use of specialized methods of fishing will need to be developed to investigate these resources effectively (Caddy, 1983). Nevertheless, some interesting aspects have emerged from this research.

With regard to the catch, though the highest hourly catches were obtained in the eastern area of the North Aegean, the largest contribution to total catch was observed in the west. However, this contribution was important mostly in the continental shelf (0-200 m) where the species of commercial interest were caught. The most abundant of them were Eledone cirrhosa and Sepia orbignyana. These species, together, with others which are quite widespread in the North Aegean, such as Sepia elegans, Alloteuthis media and Illex coindetii, are normally exploited in the western basin of the Mediterranean.

Reproduction of these cephalopods was observed during a wide range of time in accordance with what is known of their biology, as recently summarized by Boyle (1990). As a result of the prolonged spawning period, the recruitment was rather continuous even if slightly variable during different samplings. The stocks presented a somewhat fast modal progression over time and a displacement of older mature specimens after spawning periods.

The multispecies fishery in the Mediterranean poses some difficulties in drawing uniform measures for management of short-lived species, such as cephalopods, together with multi-age finfish species.

In the North Aegean Sea "closed season", from June to September, covers much of the spawning and recruitment period. However, considering the present knowledge and that stocks are more coastal, more concentrated and therefore more vulnerable to the nets during the first months of the year, the selective gear (traps, surface gillnets, etc.) may be used beneficially for the management of cephalopods. The use of a codend mesh size of 40 mm in trawl nets as opposed to 28 mm used in Greece is also necessary to protect the whole demersal resource (Charbonnier and Caddy, 1986; Giovanardi, 1986).

The short life span of cephalopods and their sensitivity to climatic variations (Cushing and Dickson, 1976; Cushing, 1981) as also observed in Greek waters (Stergiou, 1987) imply that more rapid changes in stock size from year to year may occur than for multi-age species (Caddy, 1983). Therefore, the collection of further data on size composition of the catch, permitting estimation of the growth and mortality, and the detection of the trend of abundance of the stocks in relation to the evolution of fishing effort in the area is essential.

Finally, and no less important, is the fact that the composition and distribution of Teuthofauna in the North Aegean is similar to that better-known of the western Mediterranean (Mangold-Wirz, 1973). The finding of new species both for this area and for the eastern Mediterranean, has reduced the difference between the number of known living species in this basin and in the western one. This confirms that the difference was solely due to insufficient investigation in the eastern basin (Ruby and Knudsen, 1972; Borri, 1986).

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Table 1

Catch per Unit Effort (kg/h) with standard deviation (s.d.) of cephalopods and percentage of total catch relative to depth and time from four trawl surveys carried out in the north Aegean Sea from 1990 to 1991

	Depth	June '90		Aug.-Sept. '90		Nov.-Dec. '90		Feb.-March '91	
	m	kg/h ± s.d.	%	kg/h ± s.d.	%	kg/h ± s.d.	%	kg/h ± s.d.	%
W. Area	0-500	6.65 ± 6.01	16.3	3.36 ± 3.46	7.8	2.66 ± 2.23	10.7	4.51 ± 2.48	10.3
	0-100	5.83 ± 2.47	16.2	3.59 ± 3.08	7.7	4.42 ± 0.45	16.0	6.99 ± 2.00	12.9
	100-200	9.20 ± 7.21	18.4	5.52 ± 4.99	9.5	4.38 ± 3.64	10.3	4.80 ± 0.55	10.3
	> 200	6.11 ± 7.81	15.9	2.32 ± 3.59	7.0	0.83 ± 1.27	5.8	3.08 ± 3.47	8.3
E. Area	0-500	6.57 ± 3.87	7.2	4.28 ± 4.36	4.6	7.93 ± 5.33	6.8	5.30 ± 2.18	6.6
	0-100	5.65 ± 2.83	4.9	1.73 ± 1.07	1.3	5.20 ± 1.77	2.6	4.58 ± 1.39	4.1
	100-200	7.56 ± 5.33	8.2	4.31 ± 3.24	7.3	10.05 ± 7.63	9.9	6.56 ± 1.89	9.6
	> 200	6.04 ± 2.65	7.7	5.70 ± 5.88	4.9	6.60 ± 5.44	6.8	4.08 ± 2.39	5.1

Table 2

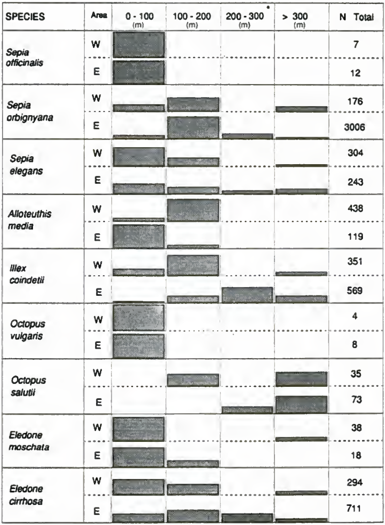
List of species found in the North Aegean Sea, relative to depth and areas, during 1990-91

		WEST AREA				EAST AREA			
Species	N Total	0-100 m	100-200 m	200-300 m °	> 300 m	0-100 m	100-200	200-300 m	>300 m
Sepia officinalis	19	+				+			
Sepia orbignyana	3 182	+	+		+	+	+	+	+
Sepia elegans	547	+	+		+	+	+	+	+
Sepiola rondeletii	2		+						
Sepiola ligulata **	1					+			
Sepiola affinis **	1						+		
Sepietta oweniana	638	+	+		+	+	+	+	+
Rondeletiola minor	44		+			+	+	+	+
Rossia macrosoma ***	126	+	+		+		+	+	+
Neorossia caroli **	54				+				+
Loligo vulgaris	76	+			+	+	+		+
Loligo forbesii	139		+				+	+	+
Alloteuthis media *	557	+	+			+	+		
Alloteuthis subulata	20	+	+				+		
Abralia verany *	2		+						+
Histioteuthis reversa *	1				+				
Illex coindetii	920	+	+		+	+	+	+	+
Todaroposis eblanae	11					+			+
Todarodes sagittatus	20				+		+		+
Octopus vulgaris	12	+				+			
Octopus salutii ***	108	+	+		+	+		+	+
Scaeurgus unicirrhus	99		+		+	+	+	+	
Pteroctopus tetracirrhus ***	17		+		+		+		+
Eledone moschata	56	+			+	+	+		
Eledone cirrhosa *	1 005	+	+		+	+	+	+	+
Bathypolypus sponsalis *	66				+			+	+

* New for the North Aegean Sea ** New for the North Aegean Sea and for the Eastern Mediterranean Sea; *** Uncertain presence in the North Aegean Sea (Mangold and Boletzky, 1987)
° No hauls were located at 200-300 m depth in the western area

Table 3

Average percentage distribution, relative to depth and areas, of cephalopods of commercial interest found in the North Aegean Sea during 1990-91



SPECIES	Area	0 - 100 (m)	100 - 200 (m)	200 - 300* (m)	> 300 (m)	N Total
Sepia officinalis	W					7
	E					12
Sepia orbignyana	W					176
	E					3006
Sepia elegans	W					304
	E					243
Alloteuthis media	W					438
	E					119
Illex coindetii	W					351
	E					569
Octopus vulgaris	W					4
	E					8
Octopus salutii	W					35
	E					73
Eledone moschata	W					38
	E					18
Eledone cirrhosa	W					294
	E					711

* No hauls were located at 200 - 300 m depth in the western area.

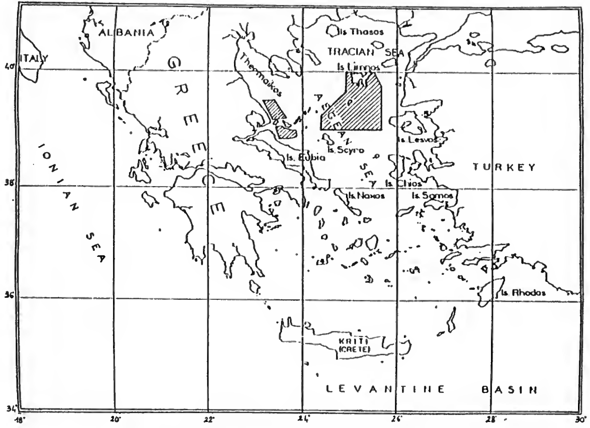


Figure 1. Areas investigated (shaded) in the North Aegean Sea during 1990-91

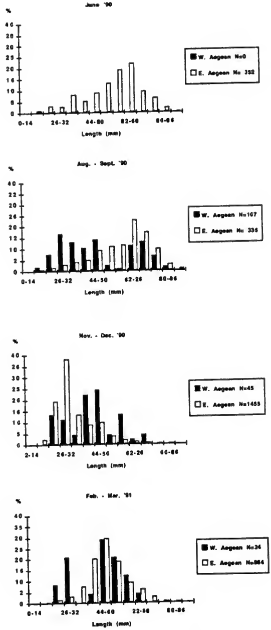


Figure 2. Length frequency distribution of Sepia orbignyana in the North Aegean Sea

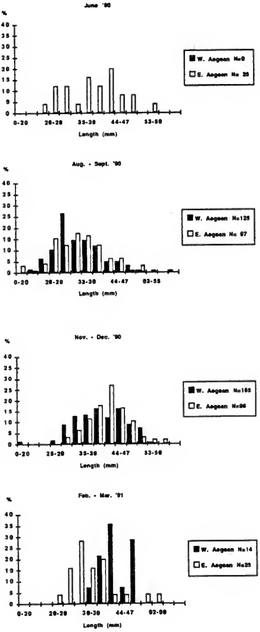


Figure 3. Length frequency distribution of Sepia elegans in the North Aegean Sea

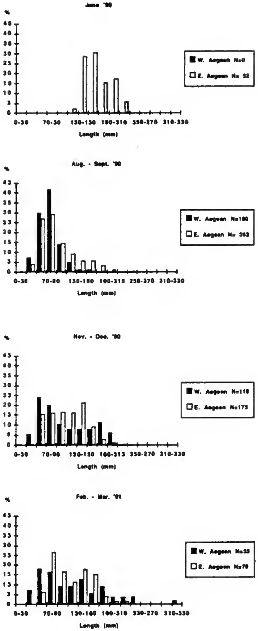


Figure 4. Length frequency distribution of Illex coindetii in the North Aegean Sea

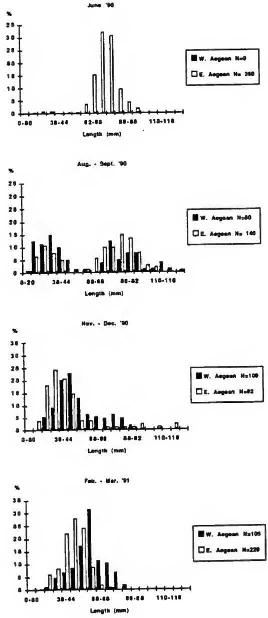


Figure 5. Length frequency distribution of Eledone cirrhosa in the North Aegean Sea

ANNEX 6

PRELIMINARY BIOLOGICAL DATA OF THE STRIPED MULLET (*Mullus surmuletus*) IN THE AEGEAN SEA

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INTRODUCTION

Striped mullet is a demersal fish, distributed throughout the Mediterranean Sea and in the eastern Atlantic from the North Sea as far as Senegal. Its biology was studied in several Mediterranean countries (Gharbi and Ktari, 1981; Andaloro and Prestipino-Giarritta, 1985; Morales-Nin, 1986).

Although it is one of the most commercially important species in Greece there is no information concerning its biology. The present preliminary study, reporting on length and age distribution, growth in length and weight, reproduction cycle, mortality, biomass and CPUE will provide valuable data for the management of the striped mullet stock in the major Greek fishing ground of the central Aegean Sea.

MATERIAL AND METHODS

Sampling took place in 30 stations in the central Aegean Sea (Figure 1). During four seasonal samplings from June 1990 till March 1991, 787 striped mullets were collected by means of a 500 HP trawler having a cod-end mesh of 14 mm from knot to knot. Fork length to the nearest millimetre, body weight to the nearest gramme, sex and maturity according Nikolsky's scale (1976) were recorded for a large number of individuals. Age determination was based on the otoliths of 229 fish examined under the reflected light of a stereoscope. Measurements were taken from the nucleus to the edge of each annulus and to the edge of the otolith, along the greatest radius of the otolith. Biomass was calculated according to the swept-area method (Papaconstantinou *et al.*, 1992).

RESULTS AND DISCUSSIONS

1. Length-Age Distribution

The lengths of the 451 male striped mullets ranged from 100 to 220 mm FL and those of the 336 females from 90 to 260 mm FL (Figure 2). Although a trend of females to be extended in larger length intervals than males was obvious, no significant difference was established between the length range of the main body of the two sexes, a fact mainly attributed to the relatively small sample, particularly in September 1990 and March 1991.

The bulk of the stock (over 50%) belonged to age group 2+, then came age groups 1+ and 3+ coinciding with the 35-40% of the total population (Figure 3). The abundance of specimens, particularly males, older than 3+ years declined abruptly. The oldest male striped mullet was 5+ years and the oldest female 6+.

2. Growth in length

A statistically significant difference was exhibited in the growth in length of the two sexes ($F = 14.080$, $df = 207$, $P<0.05$). Hence two regressions, one for males and one for females, were calculated between fork length (FL) and otolith radii (S):

$FL = 18.996+32.370{*}S$, $r = 0.83$, for males
$FL = 21.222+34.072{*}S$, $r = 0.89$, for females

Back-calculated lengths at each age group exhibited statistically significant differences between the two sexes ($P<0.05$) (Table 1). During the first year of life, both sexes attained over the 51% of their maximum adult size; then growth rates displayed an abrupt reduction.

Following the Ford-Walford method, the parameters of the von Bertalanffy equation based on the mean observed length of each age group were:

Loo = 380.199 mm, $k = 0.1043$, to = -2.75773, for males
Loo = 413.395 mm, $K = 0.0996$, to = -2.76995, for females

Gharbi and Ktari (1981) mentioned that male striped mullet off the Tunisian coast displayed a maximal theoretical length Loo = 199 mm, while for females Loo = 218.2 mm. In the Sicilian Channel (according to Andaloro and Prestipino-Giarritta, 1985) males presented Loo = 262 mm and females Loo=297.5 mm. The increased value of the maximum attainable size of the species in the Aegean Sea could be attributed to the non-existence of young striped mullet in the sample.

3. Growth in weight

Using the ANCOVA test in order to compare growth in weight of the two sexes, a statistically significant difference was established ($F = 5.003$, $df = 267$, $P<0.05$). Hence two regressions, one for each sex, were computed according to the relationship $W = a{*}L^{b}$:

$W = 0.00000507{*}L3.2538$, $r = 0.97$, for males
$W = 0.00000559{*}L3.2285$, $r = 0.99$, for females

The ANCOVA test also revealed differences in the growth in weight of the two sexes between different seasons (Tables 2 and 3). In detail, different growth was exhibited in both sexes between June-December and March-December. These differences seemed to be connected with the sexual maturity process which peaked during the period March-June. Because of the small number of data in the September sample ($N=11$) the values of the pairs derived after matching the data of each of the other three months with those of September should not be considered as too reliable.

4. Reproduction cycle

Mature striped mullet were collected throughout the year of the survey (Table 4). In early winter the sexual maturity of the gonads seemed to have started since specimens, particularly males, were at maturity stage IV. In spring, individuals classified in the three mature stages (IV, V and VI) were caught. In summer over 40% of both sexes were in a spent condition, while a smaller number of specimens belonged to stages IV and V. In early autumn, when a few spent striped mullet were collected, all the rest being immature, the completion of the reproduction period had started. Desbrosses (1935) reported that spawning of the striped mullet in the North Atlantic peaked in May and June.

The length at first maturity (L50) was estimated according to the regression $\ln(P/(1-P)) = a+(b^*L)$ (Gunderson, 1977), where P is the proportion of mature individuals in each length interval and L the mean length of the interval. Two regressions, one for males and one for females, were calculated from the June sample:

$\ln(P/(1-P)) = -8.66258+(0.07499^*L)$, $r = 0.94$, for males
$\ln(P/(1-P)) = -6.81912+(0.04928^*L)$, $r = 0.79$, for females

yielding $L_{50} = 115.52$ mm FL for males and $L_{50} = 138.38$ mm FL for females.

Sex ratio was in favour of males during all four seasons (Table 4). In relation to size, males were encountered more frequently up to 180 mm and females up to 190 mm length (Figure 4). Specimens larger than 230 mm were all females.

5. CPUE and Biomass

CPUE and biomass values were higher in the East Aegean than in the West (Table 5). Bathymetrically, high values coincided with the 100-200 m depth zone. The fact that increased CPUE values coincided with summer and winter indicates that catches are influenced by the biology/ecology of the species rather than by trawl fishing activities.

6. Mortality

Total mortality of striped mullet collected during the whole year of the survey was estimated from the slope of the descending limb of the catch curve to be $Z = 1.312$ years^{-1}. Natural mortality was calculated according to Pauly's equation (1983) as $M = 0.373$ years^{-1}. Fishing mortality was derived from the relationship $F = Z-M = 0.939$ years^{-1}. The exploitation rate, at $E = 0.716$, revealed overfishing of the striped mullet stock in the area under study.

4. Reproduction cycle

Mature striped mullet were collected throughout the year of the survey (Table 4). In early winter the sexual maturity of the gonads seemed to have started since specimens, particularly males, were at maturity stage IV. In spring, individuals classified in the three mature stages (IV, V and VI) were caught. In summer over 40% of both sexes were in a spent condition, while a smaller number of specimens belonged to stages IV and V. In early autumn, when a few spent striped mullet were collected, all the rest being immature, the completion of the reproduction period had started. Desbrosses (1935) reported that spawning of the striped mullet in the North Atlantic peaked in May and June.

The length at first maturity (L50) was estimated according to the regression $\ln(P/(1-P)) = a+(b*L)$ (Gunderson, 1977), where P is the proportion of mature individuals in each length interval and L the mean length of the interval. Two regressions, one for males and one for females, were calculated from the June sample:

$\ln(P/(1-P)) = -8.66258+(0.07499*L)$, $r = 0.94$, for males
$\ln(P/(1-P)) = -6.81912+(0.04928*L)$, $r = 0.79$, for females

yielding $L_{50} = 115.52$ mm FL for males and $L_{50} = 138.38$ mm FL for females.

Sex ratio was in favour of males during all four seasons (Table 4). In relation to size, males were encountered more frequently up to 180 mm and females up to 190 mm length (Figure 4). Specimens larger than 230 mm were all females.

5. CPUE and Biomass

CPUE and biomass values were higher in the East Aegean than in the West (Table 5). Bathymetrically, high values coincided with the 100-200 m depth zone. The fact that increased CPUE values coincided with summer and winter indicates that catches are influenced by the biology/ecology of the species rather than by trawl fishing activities.

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Table 1

Back-calculated fork lengths of striped mullet in the
Aegean Sea from June 1990 till March 1991
(a: for males, b: for females)

	Age				
(a)	1	2	3	4	5
N	137	113	29	2	1
Mean Back FL	101.1	134.1	156.2	171.9	184.1
C.I. (95%)	1.4	1.1	2.1	1.2	-
Mean Ann. Incr.	101.1	33.0	22.0	15.8	12.1
Ann. Incr. (%)	54.9	17.9	11.9	8.6	6.6

(b)	Age					
	1	2	3	4	5	6
N	73	57	21	10	3	1
Mean Back FL	107.7	141.5	167.3	186.1	198.8	208.1
C.I. (95%)	1.8	1.5	2.5	3.2	1.3	-
Mean Ann. Incr.	107.7	33.8	25.7	18.8	12.7	9.9
Ann. Incr. (%)	51.6	16.2	12.3	9.0	6.1	4.7

Table 2

Parameters of the length-weight relationship for striped mullets
collected seasonally from June 1990 till March 1991 in the Aegean Sea.
(a, b: parameters of the relationship $W = a*L^b$, c.i. = 95% confidence
interval of b, R = correlation coefficient, N = number of specimens)

Season	Males			Females		
	a	b	N	a	b	N
June	0.0000137	3.051	69	0.0000135	3.051	38
September	0.0011811	2.167	8	0.0000082	3.158	3
December	0.0000053	3.249	63	0.0000092	3.137	36
March	0.0000236	2.939	32	0.0000017	3.468	21

Table 3

Comparison of growth in weight of the two sexes of striped
mullet between seasons (1990-91), using the statistical
test of the analysis of covariance

Season	Males			Females		
	F	df	P	F	df	P
June-September	0.076	74	0.784	0.398	38	0.532
June-December	6.187	130	0.014*	6.637	71	0.012*
June-March	0.676	97	0.676	0.025	56	0.874
September-December	1.095	69	0.299	0.161	36	0.690
September-March	0.864	36	0.359	0.173	21	0.681
December-March	4.181	92	0.044*	7.694	54	0.008*

* statistically significant difference

Table 4

Maturity stages of the gonads of striped mullet collected in the Aegean Sea during the four seasons (1990-91) of the sampling

	Males							Females						
	I	II	III	IV	V	VI	Nm	I	II	III	IV	V	VI	Nf
Jun.	-	10.6	0.0	17.0	26.6	45.7	94	-	16.7	20.0	15.0	5.0	43.3	60
Sep.	-	52.3	31.8	2.3	-	13.6	94	-	77.8	16.7	-	-	5.5	18
Dec.	5.4	13.5	21.6	44.6	14.9	-	74	1.8	64.2	28.5	5.3	-	-	56
Mar.	-	-	-	30.3	63.6	6.1	33	4.3	34.8	47.8	8.7	4.3	-	23

Table 5

CPUE and Biomass values of striped mullet in three depth zones in the Aegean Sea during the four sampling months (J = June, S = September, D = December, M = March)

	Depth (m)	CPUE				Biomass			
		J	S	D	M	J	S	D	M
W. Aegean	0-500	-	0.39	0.05	-	-	17.60	2.01	-
	0-100	-	-	-	-	-	-	-	-
	100-200	-	1.52	0.18	-	-	17.60	2.01	-
	200-500	-	-	-	-	-	-	-	-
E. Aegean	0-500	1.37	0.18	1.33	0.47	218.09	26.94	197.59	68.75
	0-100	1.33	0.12	3.29	0.09	37.52	3.18	88.11	2.45
	100-200	2.50	0.35	1.64	0.98	180.57	23.76	108.88	65.77
	200-500	-	-	0.01	0.01	-	-	0.60	0.53

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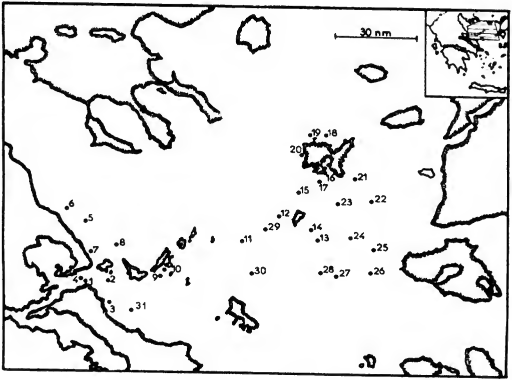
Figure 4. Sex-ratio of striped mullets in the Aegean Sea from June 1990 till March 1991



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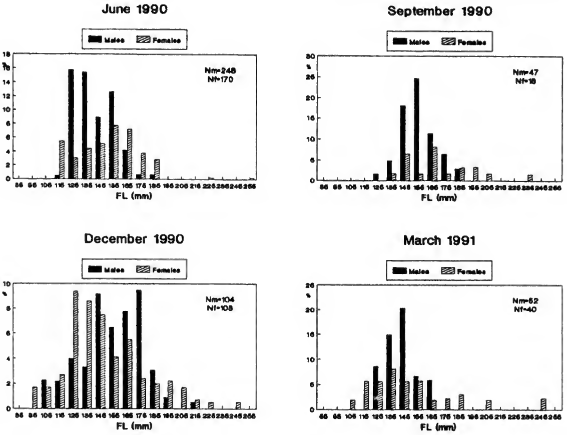

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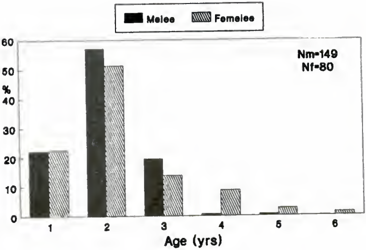

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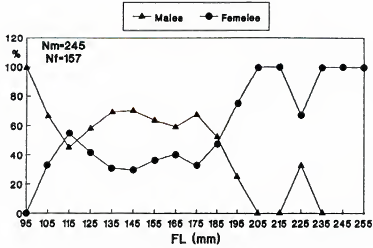

Figure 4. Sex-ratio of striped mullets in the Aegean Sea from June 1990 till March 1991

ANNEX

THE MULLIDAE (*Mullus barbatus, M. surmuletus*) FISHERY IN GREEK WATERS, 1964-1986

by

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INTRODUCTION

The Mullidae (*Mullus barbatus* and *M. surmuletus*) rank among the most commercially important demersal fish in Greek waters, representing 3.7% of the total Greek marine catch (Stergiou, 1989). Considerable research has been devoted to the study of their biology and ecology in Greek waters (see Papaconstantinou *et al.*, 1987, 1989 and references therein) but little is known about their fishery (Stergiou, 1990). The present study describes the fishery of Mullidae in Greek waters for 1964-86.

MATERIAL AND METHODS

Greek fishery statistics have been maintained on a monthly basis since 1964 (National Statistical Service of Greece, 1968-88). Greek waters have been divided into 16 fishing subareas (Figure 1). The catch of the sport fishery is not included in the grand total. In addition, since 1969 the catches of small ring-netters, drifters and liners with engine horsepower less than 19 HP are not recorded by the local authorities (their total landings amount to some 28 000 t). Available catches for 1964-81 refer to Mullidae as a group. Since 1982, separate statistics are available for *M. barbatus* and *M. surmuletus*.

The annual (1964-86) Mullidae catch and fishing effort (in HP) per major fishery (trawl, coastal) were used to assess the state of the Mullidae resources. Fishing effort (annual or monthly) per subarea is not available. According to the exponential surplus-yield model (Fox, 1970), the catch/effort U, fishing effort F, and maximum sustained yield MSY, are related as follows:

$$U = U_{\infty}e\text{-}bF \quad \text{and} \quad Y = U_{\infty}Fe\text{-}bF$$

and optimum fishing effort $F_{opt} = 1/b$; optimum catch/effort $U_{opt} = U_{\infty}/e$; and maximum sustained yield $MSY = (f_{opt})\,(U_{opt})$.

Fishing effort (in HP) of trawlers and coastal boats was standardized to a common unit of a standard gear (trawl) using the following transformation (Robson, 1966); Sparre *et al.*, 1989):

$$\text{Total HP} = 1x(HP_{trawl}) + [(CPUE_{coastal}/CPUE_{trawl})x(HP_{coastal})]$$

RESULTS

The mean (1964 to 1986) Mullidae catch amounted to 2 393 t (Table 1). Catches fluctuated between 1 567 t (1972) and 4 297 (1986). The mean (1982-86) catch amounted to 3 329 t of which 1 613 t (48.5%) were attributed to M. barbatus and 1 716 t (51.5%) to M. surmuletus (Table 1).

Subareas 8, 10, 13 to 15 and 17 made up 70.7% of the mean (1964-86) catch. Subareas 10, 14, 16 and 17 made up 64.7% of the mean (1982-86) M. surmuletus catch while subareas 8, 10, 13 and 14 made up 65.2% of the mean (1982-86) M. barbatus catch (Table 1).

The mean (1982-86) M. barbatus/M. surmuletus ratio ranged between 0.1 and 5.9 (mean 1.6) (Table 1). The ratio was <1 in subareas 7 and 16-18, >1 in subareas 3-5 and 11-14, and =1 in subareas 8-10 and 15.

Annual catches were strongly and positively correlated among the 16 subareas. Of the 120 correlations (Table 2) of annual catches between pairs of subareas, 28 were positive and highly significant ($P<0.01$), 15 were positive and significant ($P<0.05$) and only 4 were negative and significant ($P<0.05$; between 11 and 14, and between 6 and 14, 16, 17).

The mean (1964-86) Mullidae catch was allotted as follows: 1 317 t (55%) to trawl, 1 041 t (43.5%) to inshore fishery (seine and other coastal boats) and 35 t (1.5%) to purse-seine (Table 3). The purse-seine catch of Mullidae comes from purse-seiners that, in the winter, operate as trawlers; hence their catch is included in that of the trawlers. The mean (1982-86) M. barbatus and M. surmuletus catches were allotted as follows: 76.4% and 40.6% to trawling (including those of purse-seiners) and 23.6% and 59.4% to the inshore fishery respectively (Table 4).

The horsepower of trawlers and boats involved in the inshore fishery increased constantly from about 50 000 HP and 48 500 HP in 1964, to 143 000 HP and 368 500 HP in 1986, respectively (Figure 2a). During the same period, Mullidae catches increased (Figure 2b) and catch/effort decreased (Figure 2c). Fishing effort and log-transformed catch/effort were highly significantly correlated (trawl: $r = -0.72$, $P<0.001$; coastal $r = -0.76$, $P<0.001$; standardized: $r = -0.64$, $P<0.001$).

The equation describing catch/effort U as a function of standardized fishing effort F is:

$$U = 23.102\ e^{-0.0000027731}$$

and F_{opt}, MSY and U_{opt} were estimated to be: 360 600 HP, 2 903 t and 80.5 kg/HP (Figure 3).

Monthly Mullidae catches exhibit a marked seasonal pattern (Figures 4 and 5). The decrease in the monthly catches at month 72 (Figure 4) is attributed to the fact that since 1969 the catches of coastal boats with engine horsepower some <19 HP are not recorded by the local authorities. Catches are low in June-September. The pattern is similar for both species with the exception that in January-May M. barbatus catches decrease (Figure 5b) and

M. surmuletus catches increase (Figure 5c). The mean (1982-86) monthly M. barbatus/M. surmuletus catch ratio (Figure 5d) is ⟨1 in April-September and ⟩1 in the remaining months.

DISCUSSION

When the relative size of the fishing subareas is taken into account, it is evident that the mean (1964-86) Mullidae catch is higher in fishing subareas 10, 13, 14 and 8 (Table 1). The high level of Mullidae catches in these subareas must be attributed to: (a) the presence of the nutrient-rich Black Sea waters that flow along the northern and northwestern rim of the Aegean Sea (subareas 12, 13, 14) (D. Georgopoulos, NCMR, pers. comm.); the man-made eutrophication in subareas 8, 10, 13 and 14 as compared with other Greek regions (Friligos and Karydis, 1988); Friligos et al., 1988) and the high river runoff (subareas 13 and 14); and (b) the favourable conditions for trawling (extended continental shelves, smooth depths, muddy/sandy bottoms; see also below).

The M. barbatus/M. surmuletus ratio is ⟩1 in northern subareas (3, 4 and 11-14) and ⟨1 in southern ones (7 and 16-18). Subareas 11-14 represent the coldest part of the Aegean Sea and are characterized by wide continental shelves, smooth depths (Figure 1) and sandy/muddy bottoms.

The low level of Mullidae catches in June-September (Figure 4) is obviously related to the timing of the trawl and coastal seine operations in Greek waters. Both are prohibited from 1 June to 30 September (Table 5). The low summer M. barbatus/M. surmuletus ration (Figure 4d) must be attributed to the higher proportion of the M. surmuletus catch fished by coastal boats (other than seiners) (Table 4) in summer when trawling and seining are prohibited.

Although surplus-yield models have been widely employed (e.g., Charbonnier and Garcia, 1983), their application to multispecies fisheries is not without theoretical problems and practical pitfalls (Pauly, 1989a). However, surplus-yield models may be cautiously used when biological data on populations are not available despite the shortcomings of this approach (Pitcher and Hart, 1982); Pauly, 1989b). In addition, the potential use of MSY is highly controversial on biological (May et al., 1979; Healey 1986; Pauly, 1989a) and economic grounds (Mitchell, 1979). Yet, if better data are not available, MSY may be used as an initial point of a management scheme (Djama, 1989). Pauly (1989a) proposed that f(0.1), the effort corresponding to a marginal increase of catch equal to one-tenth of its increase at the lowest level of effort (Figure 3), and the corresponding yield, may be used instead of F_{opt} and MSY. In recent years the standardized combined effort of trawlers and coastal boats greatly exceeded f(0.1) for Mullidae (Figure 3). This agrees with the available studies based on biological data; M. barbatus is highly overfished in areas where trawling is allowed (south part of subarea 10 and subareas 5 and 9, 12 and 15) (Papaconstantinou et al., 1987, 1989, unpubl. data).

Fox's (1970) model is not used here for the proposal of any particular management scheme, but is used rather for the extraction of general fishery trends. However, a discussion on the regulations currently in force in Greece (for trawl and coastal seine; Table 5) is relevant. The multispecies nature of the trawl and coastal fisheries in Greece poses certain difficulties in drawing uniform protective measures. An example clearly illustrating this problem is the case of hake, Merluccius merluccious and M. barbatus. The appropriate mesh size for adequate protection of M. barbatus is 40 mm stretched; this size, however, is insufficient for adequate protection of hake which requires a mesh size)40 mm (Bas et al., 1985). The increase of the trawl mesh size from 28 mm (codend, stretched; Table 5) to 40 mm is strongly recommended.

Limitations in the total allowable catch or in the minimum size of marketed fish (10 cm for Mullidae in Greek waters; Table 5) are generally not recommended for multispecies fisheries inasmuch as these measures usually result in high discard rates (Beddington and Rettig, 1983). This is particularly true of M. barbatus in Greek waters in winter. Winter catches of M. barbatus are characterized by a high percentage of specimens of lengths (10 cm, which in some areas is)40% of the catch (Papaconstantinou et al., 1987). This part of the catch is either marked illegally or discarded.

Closed seasons may lead to increasing mortality beyond that prior to the application of the measure (Beddington and Rettig, 1983) and, in the long run, may also worsen the economic performance of the fishery (Pearse, 1980). Closed seasons also impose a disrupting effect on marketing. This is true of Mullidae (and of other demersal fish) in Greek waters in summer (Figure 5). Such an effect imposes severe economic problems; the high demand for demersal fish in summer, combined with their scarcity due to trawl prohibition, drive prices of demersal fish high (Stergiou, 1990). Experimental closing and opening of seasons/areas are recommended before the permanent application of the measure.

Restrictions on the number of licences issued, on the other hand, may be successful when introduced early in the history of the fishery (for a discussion see Meany, 1977); Pearse, 1980; Beddington and Rettig, 1983).

The measures discussed above must be spatially adapted since fishing intensity is not uniform throughout the 16 subareas. Regulation of the Mullidae fishery is probably urgent in subareas 13 and 14 (for both species), subareas 8, 10 (for M. barbatus) and 16 to 18 (for M. surmuletus) where trawl as well as inshore fishing activities are most intense (Stergiou, 1989).

The significant positive correlations found between the annual catches of Mullidae in the 16 fishing subareas (Table 3) possibly indicate that a widespread factor (or factors) may be implicated (e.g., social, climatic).

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Table 1

Mullidae catches (in t) per fishing subarea (S3 to S18: see Figure 1) in 1964-1986 and M. barbatus/M. surmuletus catch ratio per fishing subarea in Greek waters in 1982-1986. CV = coefficient of variation

	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18
	Total mullidae catch															
1964	36	61	105	26	68	188	31	188	39	91	335	223	263	136	148	126
1965	34	68	117	24	89	285	24	167	48	106	336	255	236	149	228	172
1966	36	57	114	26	79	275	26	241	35	53	317	280	263	143	296	136
1967	48	49	131	30	64	275	27	251	24	71	290	285	275	126	201	126
1968	54	53	96	29	55	317	27	423	23	75	429	273	300	105	248	137
1969	56	37	95	34	69	317	31	392	31	75	409	226	266	145	274	131
1970	33	16	66	17	24	150	19	127	9	38	262	270	158	111	181	123
1971	37	15	49	13	32	155	16	144	15	43	399	236	160	88	163	95
1972	26	14	47	7	35	126	14	143	10	53	217	266	207	79	213	90
1973	14	11	44	1	42	168	41	126	6	71	309	235	164	109	238	110
1974	16	19	60	21	49	141	51	115	7	114	238	349	233	109	198	130
1975	6	15	71	20	55	161	61	123	5	141	262	348	320	104	160	164
1976	16	14	101	19	55	140	20	204	1	90	308	332	291	94	316	187
1977	26	23	107	14	39	158	13	222	18	54	278	315	262	92	274	153
1978	22	30	88	35	30	215	25	159	11	101	407	332	304	106	233	169
1979	24	39	89	48	40	266	23	209	5	134	391	358	265	116	237	126
1980	52	22	92	16	41	274	16	285	14	236	359	302	161	202	301	115
1981	40	15	157	22	39	219	44	215	0	114	296	312	165	225	330	141
1982	26	27	171	13	59	307	24	264	6	89	336	355	194	215	399	139
1983	41	37	163	1	66	279	16	243	3	142	334	307	233	227	368	201
1984	58	28	119	0	82	291	39	279	4	120	645	415	183	349	431	241
1985	64	43	96	0	66	274	26	396	5	244	662	608	186	425	473	209
1986	61	52	65	2	79	188	11	1144	4	439	647	577	205	188	451	188
Mean	36	33	98	16	54	225	27	263	14	117	368	325	231	158	277	148
%	1.5	1.4	4.1	0.7	2.2	9.4	1.1	11.0	0.8	4.9	15.4	13.6	9.7	6.6	11.6	6.2
CV	44	57	35	68	31	29	42	76	91	73	33	29	22	53	34	25
	Mullus barbatus															
1982	16	22	26	0	23	167	7	158	6	59	266	250	83	57	46	33
1983	27	27	79	1	19	139	8	113	3	89	272	213	129	107	31	47
1984	35	22	70	0	24	169	27	150	3	99	489	291	106	163	31	55
1985	37	33	60	0	3	151	12	188	4	113	438	385	92	150	43	57
1986	45	36	48	0	15	89	6	483	4	222	512	333	112	25	68	58
Mean	32	26	57	0	17	143	12	216	4	116	396	295	100	101	44	52
%	2.0	1.7	3.5	0.0	1.0	6.9	0.7	13.5	0.2	7.2	24.5	16.3	6.2	6.2	2.7	3.2
	Mullus surmuletus															
1982	12	5	145	13	36	140	18	105	0	30	70	104	131	158	353	106
1983	14	9	84	0	47	140	8	131	0	53	82	94	104	120	337	155
1984	22	5	49	0	58	122	13	129	1	21	157	124	76	186	400	177
1985	27	10	37	0	63	123	14	208	2	131	223	224	94	274	430	152
1986	16	16	17	2	84	99	6	661	0	217	136	244	93	161	383	128
Mean	16	9	66	3	54	125	12	247	1	90	129	158	100	180	361	143
%	1.1	0.5	3.9	0.2	3.1	7.3	0.7	14.4	0.0	5.3	7.5	9.2	5.8	10.5	22.2	6.4
	Mullus barbatus/Mullus surmuletus ratio															
1982	1.3	4.9	0.2	0.0	0.6	1.2	0.4	1.5	0.0	1.9	3.8	2.4	0.5	0.4	0.1	0.3
1983	1.9	3.0	0.9	0.0	0.4	1.0	1.0	0.9	16.0	1.7	4.4	2.3	1.2	0.9	0.1	0.3
1984	1.6	4.1	1.4	0.0	0.4	1.4	2.1	1.2	2.6	4.8	3.1	2.4	1.4	0.9	0.1	0.4
1985	1.4	3.2	1.6	0.0	0.0	1.2	0.8	0.9	2.5	0.9	2.0	1.7	1.0	0.5	0.1	0.4
1986	2.8	2.2	2.6	0.2	0.2	0.9	0.8	0.7	9.3	1.0	3.6	1.4	1.2	0.2	0.2	0.5
Mean	1.8	3.5	1.4	0.0	0.3	1.1	1.0	1.0	5.9	2.1	3.4	2.0	1.1	0.6	0.1	0.4

Table 2

Pearson correlation coefficients between mullidae catches in the 16 fishing subareas, Greek waters, 1982-1986
* = p<0.05, ** = p<0.001

	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17
S4	0.43*														
S5	0.22	0.27													
S6	-0.20	0.29	0.08												
S7	0.49*	0.62**	0.39	-0.18											
S8	0.60**	0.49*	0.80**	0.21	0.53**										
S9	-0.31	-0.16	0.04	0.13	0.11	-0.23									
S10	0.82**	0.35	-0.03	-0.24	0.49*	0.21	-0.33								
S11	0.17	0.72**	0.06	0.43*	0.31	0.31	-0.10	-0.08							
S12	0.45*	0.19	-0.06	-0.33	0.37	0.10	-0.17	0.81**	-0.30						
S13	0.72**	0.29	-0.01	-0.32	0.50*	0.41	-0.14	0.87**	-0.15	0.64**					
S14	0.37	0.04	0.02	-0.42*	0.34	0.07	-0.08	0.62**	-0.50*	-0.78**	0.72**				
S15	-0.28	0.35	0.20	0.60**	0.23	0.10	0.12	-0.05	0.33	0.18	-0.20	-0.14			
S16	0.63	0.14	0.42*	-0.49**	0.48*	0.50*	0.09	0.28	-0.25	0.46*	0.71**	0.65**	-0.41		
S17	0.56**	0.04	0.42*	-0.53*	0.51*	0.43*	-0.19	0.59**	-0.40	0.58**	0.70**	0.74**	-0.30	0.80**	
S18	0.31	0.17	0.38	-0.35	0.57**	0.28	0.06	0.33	-0.25	0.42	0.62**	0.63**	0.13	0.66**	0.68**

Table 3

Annual fishing effort in HP of trawlers and coastal boats
and Mullidae catches (in tons) per fishing gear in
Greek waters, 1964-1986

	Fishing effort		Mullidae catches		
Year	trawler	coastal	trawler	purse	coastal
1964	50 047	48 470	1 010	5	1 064
1965	50 643	51 362	1 033	9	1 295
1966	51 313	56 034	975	13	1 408
1967	53 814	61 650	984	10	1 282
1968	56 227	79 675	1 067	19	1 556
1969	58 730	86 552	1 136	8	1 445
1970	63 497	60 226	1 081	6	518
1971	65 786	68 779	1 057	10	591
1972	64 115	70 029	947	7	611
1973	86 263	90 663	1 039	13	637
1974	94 424	101 513	1 258	16	594
1975	107 337	117 814	1 306	9	689
1976	111 759	127 819	1 340	14	837
1977	107 352	153 750	1 113	29	906
1978	114 648	180 337	1 284	21	962
1979	118 088	201 596	1 760	25	582
1980	123 360	226 517	1 502	41	925
1981	128 659	251 463	1 239	60	1 035
1982	132 168	279 890	1 494	40	1 091
1983	135 703	308 288	1 378	49	1 234
1984	139 156	330 005	1 619	108	1 557
1985	135 819	346 516	1 988	139	1 649
1986	142 962	368 512	2 673	158	1 465
Mean	95 299	159 455	1 317	35	1 041
%			55.0	1.5	43.5

Table 4

Mullus barbatus and M. surmuletus catches (in t)
per major fishing gear in Greek waters, 1982-1986

	Total	trawl	purse	coastal
Year	Mullus barbatus			
1982	1 199	953	10	236
1983	1 303	896	60	347
1984	1 743	1 177	74	492
1985	1 765	1 250	87	428
1986	2 054	1 577	79	398
Mean	1 613	1 170	62	380
%		72.6	3.8	23.6
Year	Mullus surmuletus			
1982	1 426	541	30	855
1983	1 358	428	43	887
1984	1 541	442	34	1 065
1985	2 012	739	52	1 221
1986	2 242	1 096	79	1 067
Mean	1 716	649	48	1 019
%		37.8	2.8	59.4

Table 5

Regulations currently in force (trawl and coastal seine) in Greek waters

Vessel licensing	Limited entry to the fishery; no increase of total tonnage
Trawlers	Closed season from 1 June to 30 September Minimum mesh size (cod end) 28 mm Fishing is prohibited inside 1 or 2 miles off the coast Many gulf and bays are closed Prohibited 3 miles off river estuaries
Beach seiners	Closed season from 1 June to 30 September Minimum mesh size 16 mm (stretched) Fishing no further than 70 m from beach Many gulfs and bays are closed Fishing is prohibited at night No new entries are permitted
Fish size limits	Prohibited to land fish with size less than 8 to 16 cm according to species (mullidae 10 cm)

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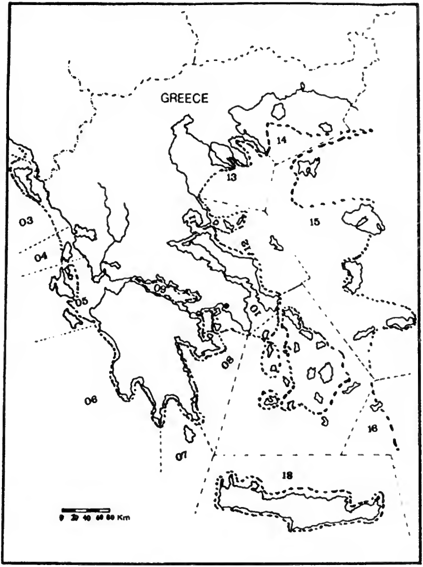

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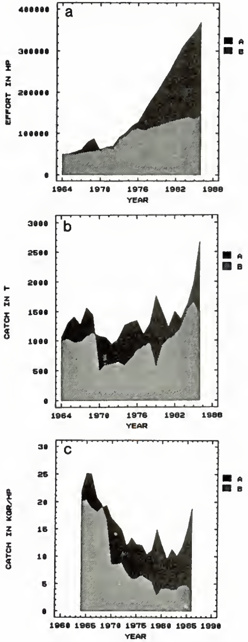

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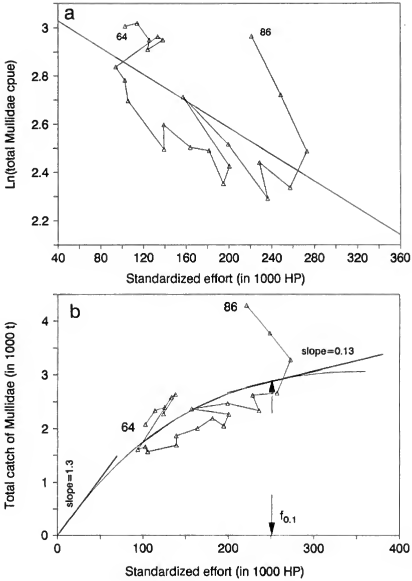

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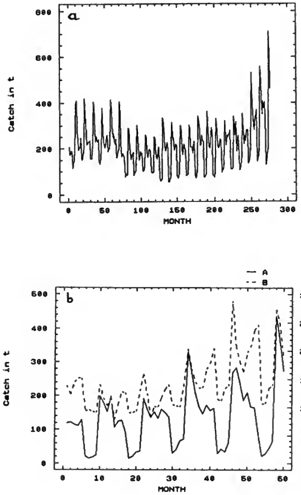

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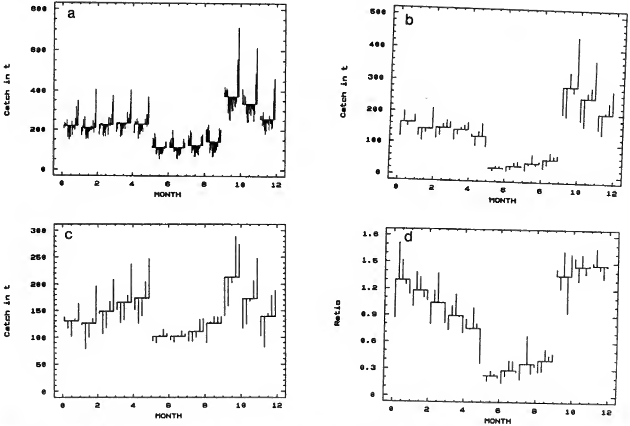

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ASPECTS OF THE BIOLOGY AND DYNAMICS OF RED MULLET (Mullus barbatus) IN THE AEGEAN SEA

by

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INTRODUCTION

Red mullet is commercially among the most important fish species in Greece. It exhibits a wide distribution in the Mediterranean Sea and is collected down to depths of 200 m.

This study provides information on length and age composition, growth, reproduction, as well as biomass, CPUE and mortality of the species in the Aegean Sea, in an attempt to achieve better knowledge and hence management of its resources.

MATERIAL AND METHODS

Sampling was carried out in 33 stations in the central Aegean Sea (Figure 1); 27 086 red mullets were collected during four seasonal samplings from June 1990 to March 1991 from a 500 HP trawler having a cod-end of 14 mm mesh from knot to knot.

Fork length to the nearest millimetre, body weight to the nearest gramme, sex and maturity according to Nikolsky's scale (1976) were recorded for a large number of individuals. Age determination was based on otolith readings and biomasss was calculated according to the swept area method (Papaconstantinou et al., 1992).

RESULTS AND DISCUSSION

1. Length and Age Distribution

Figure 2 shows that red mullet fork lengths in the Aegean Sea ranged from 60 to 230 mm FL, the majority of the stock consisting of specimens 80-150 mm long. Young individuals of 60-80 mm were collected mainly in September.

The length frequency distribution of the 3 315 sexed individuals is presented in Figure 3. Male red mullets exhibited a mode at 110-140 mm and females at 130-160 mm in length extending to 230 mm; while lengths of males did not exceed 200 mm. The dominant age group was 1+ for males and 2+ for females and both age groups coincided with more than 90% and 77% of the two sexes respectively (Figure 4). Red mullet older than 3 years appeared very infrequently in the sample.

2. The von Bertalanffy Equation

The parameters of von Bertalanffy's equation were estimated according to the Ford-Walford method based on the mean observed length of each age group for the two sexes separately:

Loo = 227.19 mm, k=0.2501, to = -1.8535 for males
Loo = 254.97 mm, k=0.2135, to = -2.1335 for females

Haidar (1970) found that in the Adriatic the maximum asymptotic length for males was Loo = 200 mm and for females Loo = 264 mm. Gharbi and Ktari (1981) found in Tunisian waters that for males Loo = 180.9 mm and for females Loo = 204.4 mm. Papaconstantinou et al. (1981) reported that the asymptotic length for male red mullets in Thermaikos Gulf (Greece) was Loo = 209.1 mm and for females Loo = 275.4 mm, while in Saronikos it was Loo = 192.3 for males and Loo = 244.9 for females. Livadas (1988) calculated for male red mullet off Cyprus Loo = 220 mm and for females Loo = 284 mm. Vassilopoulou (1989) estimated for males in the Euboean Gulf Loo = 236.04 mm and for females 316.1 mm. Thus, it is obvious that there is no significant difference in the growth of the species in Greek and Cypriotic waters, the only slight divergence coinciding with the findings in the Euboean Gulf, where red mullets reach greater observed lengths (~300 mm) possibly because in this area there are sites where trawling is prohibited.

3. Growth in Weight

No statistically significant difference was observed in the growth in weight of the two sexes, when the ANCOVA test was applied to the data ($F = 1.133$, df = 1465, $P>0.05$). Hence the length-weight relationship for red mullet in the Aegean Sea, sexes combined, was:

W = 0.000006442*L3.179, r = 0.99

The confidence interval of the exponent b, being 3.179+0.035, implied an allometric growth of the species in the Aegean Sea yielding individuals heavier for their size.

Seasonal length-weight relationships are shown in Table 1. An isometric growth was exhibited in summer and autumn, coinciding with the spawning of the species and an allometric one (heavier individuals) in winter and spring.

4. Reproduction Cycle

The sexual maturity of red mullets in the Aegean Sea began in early spring and extended till late autumn (a small number of spent individuals was collected in the November-December 1990 cruise) (Table 2). Spawning peaked in June, while in September almost 25% of the specimens was in a spent condition.

Length at first maturity (L_{50}) is estimated by the regression $\ln(P/(1-P)) = a+(b^*L)$ (Gunderson, 1977) where P is the proportion of mature individuals in each size interval and L the mean length of the interval was used. Two regressions were calculated for the June sample, one for males with $a = -8.801$ and $b = 0.09363$ yielding $L_{50} = 93.989$ mm and the other for females with $a = -14.618$ and $b = 0.14065$ yielding $L_{50} = 103.931$ mm. Bougis (1952) found that off southern France male red mullets attained sexual maturity at 110-120 mm TL and females at 130-140 mm TL. Papaconstantinou et al. (1981) observed that in two Greek gulfs L_{50} for males was found to be 100-150 mm and for females 120-130 mm. Livadas (1988) reported that off Cyprus both sexes matured for the first time at a length of 90-100 mm.

Seasonal sex ratio showed no significant variations from the 1:1 theoretical value (Table 2). In relation to size, males were more numerous in < 130 mm length intervals and females in the > 140 mm ones, while in the 130-140 mm sex ratio tended to the expected 1:1 value (Figure 5). Individuals larger than 200 mm were all females. Similar observations were made by Larrañeta and Rodriguez-Roda (1956) in Spanish waters, Hashem (1973) off the Egyptian coast and Vassilopoulou (1987) in the Saronikos Gulf (Greece).

5. CPUE and Biomass Values

Both CPUE and biomass values were higher in the northern part of the Aegean than in the western part, a fact attributed to the existence in the former area of relatively shallower waters where red mullets prefer to inhabit (Table 3). In relation to depth increased values were in most cases observed in the 0-100 m depth zone. In the northern Aegean high autumn values in the latter depth zone are related to the recruitment of young red mullet (60-80 mm) (Figure 1). In the western Aegean increased values in shallow waters in spring are due to the presence of specimens 100-120 mm long. Trawl fishing activities do not seem to have a pronounced effect on the catches, variations exhibited being largely in the range of the biology-ecology of the species.

6. Mortality

The total mortality of red mullet, sexes combined, for the whole year of the survey was estimated from the slope of the descending limb of the catch curve as $z = 1.278$ years^{-1}. Arneri and Jukic (1985) reported that the instantaneous mortality rate of red mullet in the Adriatic was $z = 1.64$ years^{-1}.

The natural mortality was calculated according to Pauly's equation (1983) as $M = 0.481$ years^{-1}. Hence, the fishing mortality was $F=0.797$ years^{-1}. The high total and natural mortality seemed to be closely with the limited number of young individuals in the catches. The exploitation rate, at $E=0.623$, indicated that the red mullet stock in the Aegean Sea is overfished.

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Table 1

Parameters of the length-weight relationship for the red mullets collected seasonally from June 1990 till March 1991 in the Aegean Sea (a, b: parameters of the relationship W = a*LB, c.i. = 95% confidence interval of b, R = correlation coefficient, N = number of specimens)

	a	b	c.i.	R	N
June	0.0000119	3.044	0.071	0.96	610
September	0.0000077	3.142	0.151	0.92	316
December	0.0000074	3.156	0.055	0.98	472
March	0.0000038	3.288	0.049	0.99	438

Table 2

Maturity stages (%) of the gonads of red mullet collected in the Aegean Sea during the four seasons of the sampling

	Males							Females						
	I	II	III	IV	V	VI	Nm	I	II	III	IV	V	VI	Nf
Jun.	-	1.2	3.3	24.1	61.6	9.8	482	-	1.5	1.7	7.1	88.5	1.2	401
Sep.	2.1	36.8	16.6	5.6	14.2	24.7	198	0.9	59.6	12.3	0.9	0.9	25.4	205
Dec.	14.5	27.6	57.3	-	-	0.6	199	12.4	48.8	38.3	-	-	0.5	198
Mar.	6.6	18.2	37.0	36.5	1.7	-	378	10.8	25.2	60.7	3.3	-	-	144

Table 3

CPUE and Biomass values of red mullet in three depth zones in the Aegean Sea during the four sampling months (J = June, S = September, D = December, M = March)

	Depth (m)	CPUE				Biomass			
		J	S	D	M	J	S	D	M
W. Aegean	0-500	1.22	1.38	1.30	2.35	51.53	159.39	58.05	107.67
	0-100	2.01	2.73	4.34	7.56	21.89	80.30	49.57	88.26
	100-200	2.80	2.70	0.76	1.68	29.64	78.15	8.48	19.40
	200-500	-	-	-	-	-	0.89	-	-
N. Aegean	0-500	13.32	14.30	14.65	10.67	2115.80	2178.20	2212.41	1684.10
	0-100	32.89	71.20	70.91	47.56	925.72	1916.60	1898.90	1348.50
	100-200	16.48	3.85	4.44	4.82	1190.10	261.60	295.38	323.05
	200-500	-	-	0.31	0.21	-	-	18.12	12.60

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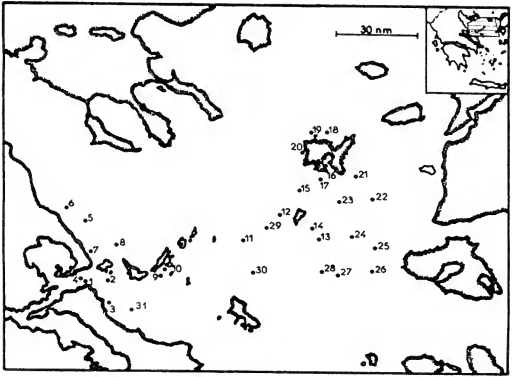
Figure 4. Age distribution of male and female red mullets in the Aegean Sea

Figure 5. Sex-ratio of red mullets in the Aegean Sea from June 1990 till March 1991



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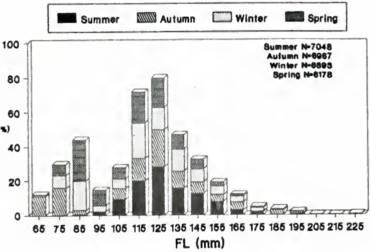

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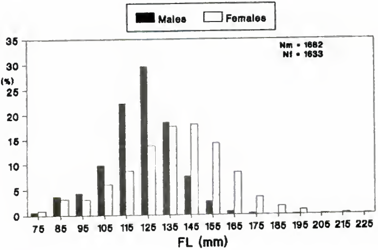

Figure 3. Length frequency distribution of male and female red mullet collected in the Aegean Sea

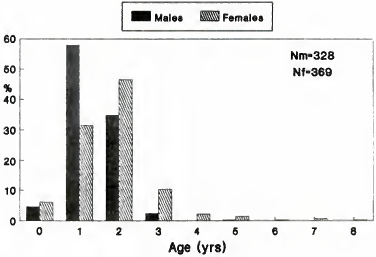

Figure 4. Age distribution of male and female red mullets in the Aegean Sea

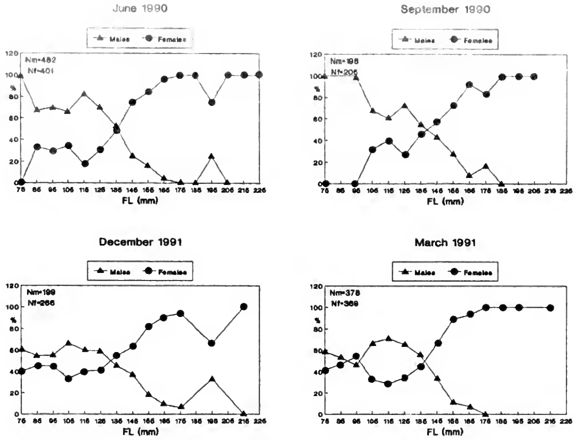

Figure 5. Sex-ratio of red mullets in the Aegean Sea from June 1990 till March 1991

PRELIMINARY STUDY ON THE BIOLOGY OF PIPER (Trigla lyra, L., 1758) IN THE AEGEAN SEA

by

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INTRODUCTION

The gurnards or searobins are marine demersal fishes found in all oceans. In the Mediterranean Seas five genera, represented by eight species, have been identified. Different aspects of their biology have been studied in recent years: Svedovidov (1936) described the taxonomic status of the Black Sea species. Priol (1932), Mouneimne (1970), Kartas (1970) and Baron (1985) studied the biology of gurnards off the Mediterranean French coast. Papaconstantinou (1983) studied the ecology of different gurnard species in the Greek seas and described in detail the anatomy of the head and the pectoral girdle (Papaconstantinou, 1984).

The piper (Trigla lyra L., 1758) is a demersal gurnard that lives in muddy bottoms down to a maximum of 400-450 m depth. It is found in the Mediterranean and in the eastern Atlantic, from the western coast of Great Britain to the Gulf of Guinea (Whitehead et al., 1984-86). Mouneimne (1970) and Papaconstantinou (1981) studied its biology in the area off Banyuls-sur-mer (Mediterranean coast of France) and the Saronikos Gulf (Greece) respectively. The piper, together with Trigla lucerna, are the most commercially important gurnards in Greece.

The objective of this study was to provide information on growth, length-age composition, reproduction and mortality of the piper in the Aegean Sea, which will be useful to manage the fishery of the species in the area.

MATERIALS AND METHODS

The study was based on 2 180 pipers caught in the Aegean Sea (Figure 1) from June 1990 to March 1991 on a seasonal basis. Sampling took place using a commercial bottom trawler of 500 HP, which had a net with a cod-end mesh size of 14 mm from knot to knot. The duration of each trawl haul varied between 45 and 60 min. The fork length to nearest millimetre and the weight to the nearest 0.1 g were recorded. The sex was verified macroscopically for adults and microscopically for juveniles.

Age was determined by the otoliths (sagittae). They were cleaned and preserved in glycerine until the time of study. Different methods for reading the otoliths were used.

The best results were obtained after burning the otoliths at about 450°C for 2 minutes. The burning enhances the visibility of the annuli because the hyaline zones become brown while the opaque zones remain white. The otoliths were then placed in a black-painted Petri dish containing glycerine, with the concave surface up, and illuminated with reflected light, and read under a binocular microscope magnified 18X.

The standing stock of the population was estimated by the swept-area method (Papaconstantinou et al., 1992).

Growth was expressed in terms of the von Bertalanffy
(1957) equation:

$$L_t = L_{\infty}(1\text{-exp-}k(t\text{-}to))$$

where L at the time t is expressed as a function of three parameters, the asymptotic length L_{∞}, the growth constant k and an extrapolated constant to; k and L_{∞} were estimated according to the Tomlinson and Abramson's (1961) method.

Total mortality (Z) was computed from the catch curve as well as from the length-converted catch curve (Pauly, 1983). Natural mortality (M) was estimated from the empirical formula of Pauly (1983):

$\log M = -0.0066 - 0.279 \log L_{\infty} + 0.6543 \log k + 0.4634 \log T$ where T is the mean annual temperature of the sea water and L_{∞} the asymptotic length in cm. The exploitation rate was determined from the relation: $E = F/F+M$, where F is the fishing mortality and E is the exploitation rate.

The yield-per-recruit was calculated using the analytical model of Beverton and Holt (1957) as simplified by Gulland (1983).

RESULTS

1. Length/age frequency distribution

The length-frequency distribution from the West and North Aegean Sea over the period June 1990 to March 1991, based on fork lengths at capture, is illustrated in Figure 2. The fork length of 2 180 measured pipers ranged from 43 to 472 mm. No significant differences were found in the mean length of fish between males and females, hence the two sexes were combined.

The bulk of the specimens was caught in the North Aegean Sea. The young-of-the-year (45-75 mm) recruit in the Aegean Sea in autumn. A few juveniles were caught in early summer, with a modal length of 45-75 mm, representing the beginning of the recruitment. A shifting of the mode (66-86) towards greater lengths is obvious between November 1990 (89-129 mm) and March 1991 (105-135 mm). The length distribution suggests that the population consists of some year classes but only the modes at approximately 110-129 mm and 179-209 mm probably represent individuals belonging to age groups I and II.

The greater part of the pipers caught in the area belongs to 0 and I age group (Figure 3). Between autumn 1990 and March 1991 the bulk of the fished population ranging from 37 to 80% and 43 to 80% respectively in the West and North Aegean Sea belongs to the 0-group. The high proportion of 0-group dropped to less than 15 and 10% respectively in summer, reinforcing the view that the first annulus is formed in spring.

2. Bathymetrical distribution

Piper prefers medium (100-200 m) and deeper waters (>200 m), while its abundance declines in inshore waters. The depth distribution of the species varied between 100 and 325 m. The young-of-the-year, which recruit in June and September, appeared almost exclusively at depths >200 m, while at the same time most of the I+ and II+ specimens were distributed in the 100-200 m depth zone. A shift of larger fish towards greater depths was obvious, since at depths >200 m the relative abundance of fish older than II years is greater.

3. Biomass distribution

The biomass per km^2 are shown in Table 1; in general, it is higher in June whereas a second peak occurs in December in the North Aegean. The biomass was found to be higher in the North Aegean Sea than in the West Aegean Sea and for the 100-200 m depth zone than the remaining ones.

4. Growth in weight

The length-weight regression has been calculated by the least squares method for each season, sexes combined.

June : $W = 0.000007 \times FL3.031$ $r = 0.99$
September : $W = 0.000013 \times FL2.913$ $r = 0.99$
December : $W = 0.000028 \times FL2.768$ $r = 0.97$
March : $W = 0.000013 \times FL2.911$ $r = 0.98$

where W is the weight in grammes, FL is the total length in millimetres and r is the coefficient of correlation.

5. The Von Bertalanffy equation

The following von Bertalanffy's equation, based on the mean observed length-at-age for 1990-1991, was computed:

$$L_{\infty} = 574.38\ (1\text{-}e\text{-}0.169(t+1.245))$$

6. Maturity stages and sex ratio

Although few mature individuals were collected in June, spawning probably takes place in summer because no mature individuals were found in the remaining seasons.

The sex ratio did not differ significantly from 1 in September whereas it was in favour of females in June and of males in November-March.

7. Mortality estimation

Natural mortality, calculated according to Pauly's (1983) equation, was M = 0.332. Total mortality, estimated from the slopes of the catch curve and the length-converted catch curve (Pauly, op. cit.), were respectively: 0.451 and 0.596. The exploitation rate for each method was respectively: 0.618 and 0.642.

8. Yield per recruit

Estimates of growth and mortality parameters provide all the information necessary to compute the yield-per-recruit of piper in the North Aegean Sea for 1990-1991. In this area piper is vulnerable to capture at Tc = 0.7. The relation between yield-per-recruit and fishing mortality F for different values of Tc and M is shown in Figure 4.

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Table 1

Biomass distribution (t^*/km^2) of piper from
June 1990 to March 1991

Regions	Bathymetry in m:	June	September	December	March
W. Aegean	0-500	0.015	0.009	0.003	0.004
	0-100	-	0.002	0.001	0.004
	100-200	0.058	0.022	0.009	0.002
	200-500	0.001	0.007	0.001	0.005
N. Aegean	0-500	0.059	0.040	0.061	0.040
	0-100	0.016	0.018	0.009	0.005
	100-200	0.099	0.068	0.102	0.066
	200-500	0.030	0.015	0.035	0.024

LIST OF FIGURES

Figure 1. Map of the study area with the sampling stations

Figure 2. Length frequency distribution of piper from summer 1990 to spring 1991 in the East and West Aegean Sea

Figure 3. Age distribution of piper from summer 1990 to spring 1991 in the North and West Aegean Sea

Figure 4. Relation between Y/R and fishing mortality rate (F) of piper for different values of natural mortality rate (M)

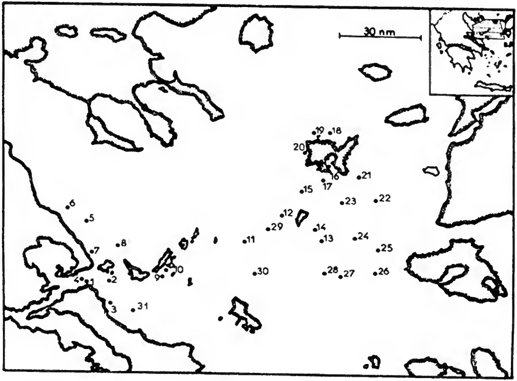


Figure 1. Map of the study area with the sampling stations

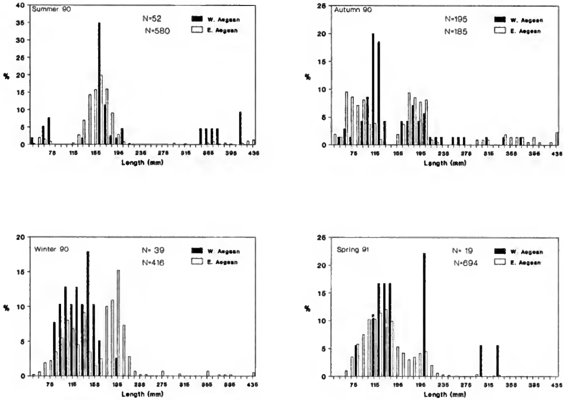


Figure 2. Length frequency distribution of piper from summer 1990 to spring 1991 in the East and West Aegean Sea

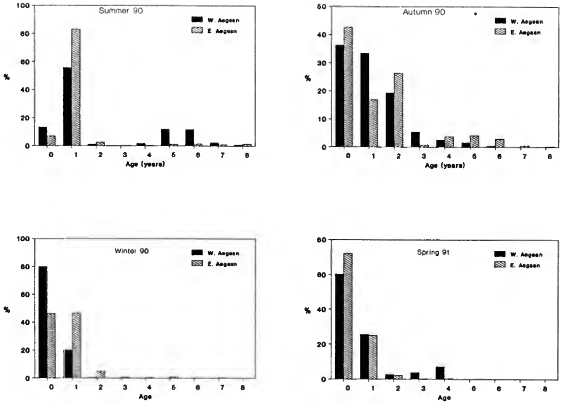
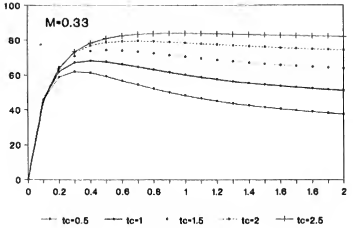


Figure 3. Age distribution of piper from summer 1990 to spring 1991 in the North and West Aegean Sea



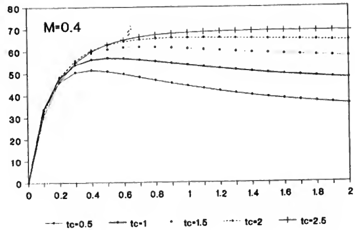


Figure 4. Relation between Y/R and fishing mortality rate (F) of piper for different values of natural mortality rate (M)

A PRELIMINARY STUDY ON THE FISHERY BIOLOGY OF HAKE IN THE AEGEAN SEA

by

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INTRODUCTION

Hake (Merluccius merluccius L., 1758) is a gadoid fish species with a geographical distribution extending throughout the Mediterranean Sea and the Atlantic Ocean, from Iceland to Morocco, occurring at depths from shallow waters down to about 700 m. Hake is very common and one of the most valuable foodfishes in the Greek seas; annual catches from 1985 to 1990 have been approximately 2500 t. Recently various aspects of the life history of hake in the Greek seas have been studied (Yannopoulos, 1977; Caragitsou and Tsimenidis, 1977; Tsimenidis et al., 1978; Papaconstantinou and Caragitsou, 1987, 1991; Papaconstantinou and Stergiou, 1987). Although considerable research has been devoted to the study of its biology in Greek waters, questions have arisen concerning seasonal migration and oscillation in the abundance of the 0-group hake; the latter declines abruptly between September and December in areas considered to be nursery grounds as compared to areas where mature hake predominate.

The purpose of this study is to investigate certain aspects of the life history of hake in the Aegean Sea. Findings on age, growth, mortality, biomass, sexual maturity and yield per recruit are presented.

MATERIAL AND METHODS

1. Description of the Geographical Area Under Study

The study area is shown in Figure 1. In selecting this area the following points were taken into consideration:

- It is the largest trawl fishing ground in the Greek seas and the only one with indications of increase in commercial hake catches
- The area presents an increased year-by-year rate of exploitation
- The area is not yet heavily exploited. Most of the fishing areas are known since 1950, and the skippers/owners of the boats are not prepared to risk the safety of their fishing equipment in order to discover new ones

The area is divided in two subareas, North and West Aegean Sea, each of which is again subdivided into zones according to depth.

Sampling took place on a seasonal basis in 1990-1991 by a 500 HP commercial trawler, towing a 28 mm stretched net, chosen from among Greek trawlers which usually perform fishing in the area. Trawling was carried out during the day whereas sampling on a 24-hour took place only in the hake nursery grounds basis. Thirty-three fishing stations were selected over the surveyed area. The duration of each haul was between 45 and 60 minutes depending on the season, the depth, the geomorphology of the sea-bed and the abundance of the catch. The stations were chosen so as to be representative of all biotopes, depths and fishing status of the area.

Total length to the nearest millimetre, weight to the nearest gramme, sex and gonad maturity, according to Nikolsky (1976), were recorded. Both otoliths (sagittae) were removed and preserved in labelled vials containing a 1:1 glycerine:water solution.

The standing stock of the population was estimated by the swept-area method. Knowing the speed at which the trawl moves, the opening width of the trawl, the total area under survey and the catch rates, it is possible to calculate density and thus estimate the total resources (standing stock) of the population in a defined area:

$$\text{size of standing stock} = \frac{A * C/F}{a * X_1}$$

where A = total area under survey
C/F = mean catch/effort obtained during the survey
a = area swept by the trawl in one hour
X_1 = proportion of the fish actually retained along the path of the net ($1/X_1$ = escapement factor).

Values of $X_1 = 0.7$ and $X_1 = 0.5$ were used for the unfished and fished areas respectively, taking into consideration that Andreoli et al. (1982) used $X_1 = 0.5$ off southern Sicily, an area with similar ecological conditions and analogous fishing status with the study area.

The area a swept by the trawl in one hour is $a = t*v*h$ where v is the speed of the trawler when trawling, $h \sim 13$ m the length of the trawl's head rope and t the trawling time.

Growth was modelled with the von Bertalanffy growth curve fitted to observed lengths for ages I-VIII. The von Bertalanffy parameters asymptotic length L_{∞}, growth coefficient k and time of zero length t_o, were determined using the method of Tomlinson and Abramson (1961).

Total mortality was calculated from the slopes of the catch curve (age) and the length-converted catch curve (Pauly, 1983). Natural mortality (M) was computed from the empirical formula of Pauly (1983):

$$\log M = -0.0066 - 0.279\log L_{\infty} + 0.653\log K + 0.463\log T,$$

where L_{∞} in cm, k as described above and T is the mean annual temperature of the sea water.

Yield-per-recruit was calculated using the analytical model of Beverton and Holt (1957) as simplified by Gulland (1983).

RESULTS

1. Length/Age Frequency Distribution

The seasonal length-frequency distribution of 12 324 hake is presented in Figure 2. Total length (TL) ranged from 55 to 800 mm; however, fish longer than 300 mm were scarce (Figure 1). The abundance of the young-of-the-year indicated that the area is an important nursery ground (76.5% in the West Aegean and 53.9% in the North Aegean). The young-of-the-year were represented in the nursery areas by two recruitment groups in the West Aegean (early summer and winter), whilst in the North Aegean by one (early summer), indicating that there is a lag of three months in the timing of recruitment between the two areas.

The dominant 0-group in summer in the West Aegean was easily followed from June 1990 (TL 80-100 mm) to September (TL 100-140 mm) and the following March (TL 160-180 mm), with proportional shifting of the modes towards greater lengths from summer (80-100 mm) to the following spring (160-200 mm) in the North Aegean. The abundance of fish of lengths >200 mm decreased abruptly all the year round in both areas.

The total age distribution of hake, determined by an age-length key, indicated narrow length intervals for each age group and limited overlap between adjacent age groups. The recruitment of the young-of-the-year that took place in early summer and winter in the West Aegean and in early summer in the North Aegean affected the age distribution of the stock in both areas, resulting in the widespread appearance (<60.0%) of the 0-group in the catches between summer-winter and autumn-winter respectively (Figure 3). The first annulus seems to be formed during the winter as the bulk of the hake fished in the following spring was age I in both sampling areas.

2. Bathymetrical Distribution

Hake was fished at depths of 25 to 550 m. The seasonal age distribution in relation to depth differed between and within the two sampling areas, corroborating the view that hake makes horizontal and vertical migrations. A shift of large fish towards greater depth is obvious, since in areas with depths >300 m most of the specimens caught were larger than 300 mm. No significant differences were found in the bathymetrical distribution of hake >300 mm between the North and West Aegean Sea.

3. Biomass Distribution

The mean biomass and the biomass/km^2 of hake during the sampling period were higher in the North than the West Aegean Sea (Table 1), while a significant difference was also found between the 0-200 m and >200 m depth zone in both areas. The fact that increased values of hake biomass coincided with winter-early spring indicates that catches are heavily influenced by the biology and ecology of the species which determine the spreading of the hake school and its catches.

4. Growth in Weight

The data used for the length-weight analysis were collected from 1 814 individuals. A pooled regression from all data revealed the following length-weight relationships:

June : W = 0.000003 x L3.159 r2 = 0.96
September : W = 0.000002 x L3.181 r2 = 0.98
December : W = 0.000004 x L3.077 r2 = 0.96
March : W = 0.000006 x L3.021 r2 = 0.88

where W is the weight in grammes, L is the total length in millimetres, and r is the coefficient of determination.

All slopes were greater than 3.0, indicating that longer fish had a relatively larger girthed than shorter fish.

5. The von Bertalanffy Equation

The following von Bertalanffy equation was estimated:

$$L_t = 1037.82 (1 - e-0.075(t + 1.821))$$

6. Maturity Stages and Sex Ratio

Some 2 009 hakes (1 282 males and 1 077 females) collected in four cruises between June 1990 and March 1991 were examined to determine the reproduction period. Almost 20%, sexes combined, was sexually mature in June and September, while this percentage was significantly smaller during winter and early spring.

There was no significant departure from the theoretical 1:1 sex ratio in the Aegean Sea during the 1990-1991 survey.

7. Mortality Estimation

Natural mortality was found to be 0.165. Total mortality, estimated from the slopes of the catch curve and the length-converted catch curve, were 0.723 and 0.643 respectively and exploitation rates were 0.814 and 0.796 accordingly.

8. Yield-Per-Recruit

Estimates of growth and mortality parameters provide all the information necessary to compute the yield-per-recruit of hake as a function of age at first capture (Tc) and fishing mortality rate (F). In the study area, young hake are vulnerable to capture at Tc = 0.5. The yield-per-recruit in relation to F for different values of Tc and M are shown in Figure 4.

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Table 1

Biomass distribution (t/km^2) of hake from
June 1990 to March 1991

Regions	Bathymetry in m:	June	September	December	March
W. Aegean	0-500	0.09	0.21	0.14	0.23
	0-100	0.11	0.24	0.09	0.39
	100-200	0.16	0.28	0.33	0.29
	200-500	0.05	0.15	0.07	0.13
N. Aegean	0-500	0.24	0.19	0.35	0.30
	0-100	0.33	0.29	0.33	0.42
	100-200	0.30	0.24	0.51	0.36
	200-500	0.12	0.09	0.17	0.19

LIST OF FIGURES

Figure 1. Map of the study area with the sampling stations

Figure 2. Length frequency distribution of hake in the North and West Aegean Sea from summer 1990 to spring 1991

Figure 3. Age distribution of hake in the North and West Aegean Sea from summer 1990 to spring 1991

Figure 4. Relation between Y/R and fishing mortality rate (F) of hake in the Aegean Sea for different values of natural mortality rate (M)

ICHTHYOPLANKTON DISTRIBUTION IN THE AEGEAN SEA IN SUMMER 1990

by

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INTRODUCTION

Few thorough ichthyoplankton studies have been made in Greek waters since the beginning of the century, when the Danish DANA and THOR expeditions took place and much information regarding the description of the different larval developmental stages and their distribution in the Greek seas was published (Schmidt, 1918; Taning, 1918; Ege, 1930). Recent ichthyoplankton studies in Greek waters are very limited referring mainly to enclosed gulfs and commercial fish species, e.g., anchovy and sardine (Yannopoulos, 1971; Yannopoulos and Barrois, 1975; Yannopoulos and Yannopoulos, 1979). The National Centre for Marine Research, in the framework of its fishery research activities in the Aegean Sea, organized extended ichthyoplankton surveys in the North and West Aegean Sea between June 1990 and March 1991. During this project various topics of larval biology/ecology were studied and different sampling methods/gears introduced for the first time in the eastern Mediterranean (Bongo, Mark III (Hsp) and Methot midwater-trawl) which are very effective and can sample at different depths.

This paper reviews the distribution and abundance of the fish larvae in the West and North Aegean Sea in June and July 1990.

MATERIALS AND METHODS

The bongo net, Mark III (Hsp) and Methot midwater-trawl were used for the quantitative sampling of larval stages of fish differing in size, motion and ability to escape. Sampling took place in the West and North Aegean Sea (Figure 1) in June and July 1990. In July 1990 samples were taken only from the West Aegean Sea. A dense grid of stations was designed (47 in June and 22 in July), where the bongo net was deployed with a high sampling resolution. In the West Aegean Sea supplementary sampling was also performed with the Mark III sampler at 20 stations and with the Methot midwater-trawl at selected stations (four stations at the surface and at different depths in June 1990).

The bongo net, fitted with a flowmeter and a depressor, was towed horizontally for 10-15 min (plus lowering and hauling time) at a depth of 25-30 m (at stations where the water depth did not exceed 100 m) and at 40-50 m (at stations of greater depth). The towing speed ranged between 2.5 and 3.0 knots.

The Mark III, fitted with a flowmeter and a depth recorder, was towed obliquely, from the bottom to the surface, at a speed of 5 knots.

The Methot midwater-trawl was used for sampling post-metamorphosed larvae and pelagic juvenile fish. Tows were made horizontally at the surface or at different depths between 30 and 100 m.

In the laboratory, all fish eggs and larvae were extracted and analysed according to standard techniques. Eggs and larvae were counted under a binocular stereoscope. The larvae were identified to species level (whenever possible) measured to the nearest 0.1 mm and abundance per species (n/m^3 and n/m^2) was estimated. The bongo and Mark III catches were compared for the assessment of the relative efficiency of the two instruments over the range of sizes of the species sampled.

RESULTS

1. Geographical distribution of larvae

The total number and the average concentration of eggs and larvae (all species combined) by sampling period and gear used are given in Tables 1 and 2. The abundance of both eggs and larvae was higher in the North Aegean than in the West Aegean, a fact which could be related to the abundance of fish.

The fact that within the North Aegean the abundance of larvae was higher around Limnos isle corroborates the view that this area is one of the most important fishing grounds. The apparent concentration of fish larvae in the regions sampled with the bongo and the Mark III net is presented in Table 4.

2. Species abundance: Comparative analysis between gears

Overall, 42 taxa were identified in the samples collected in June 1990. More species were found in the samples taken with the bongo net (Tables 3 and 4). However, the number of individuals per volume of filtered water was higher in the samples taken with the Mark III net. This discrepancy is due to the fact that the bongo net filters a substantially greater volume of water per haul (on average 432.89 m^3/station) than the Mark III (on average 18.69 m^3/station), permitting the sampling of rare species or life stages. This probably indicates that the sampling efficiency of this net is higher than that of the Mark III net.

Preliminary data suggest that extraction of organisms may have occurred through the meshes of the bongo net. This is particularly true of the slender-elongated larvae of Engraulis encrasicolus and S. aurita. The differences in the composition of the catches of the two samplers may be attributed to the differential avoidance by larvae of the two gears, depending on their mobility, the different depth of hauling and/or other characteristics of the tows. Future analysis will deal with the comparison of the catches of the two samplers and their relative efficiency in sampling a different spectrum of organisms and life stages.

The geographical distribution of Engraulis encrasicolus and Sardinella aurita larvae, which dominated the catches in West Aegean, is presented in Figures 2 and 3 and their length distribution in Figures 4 and 5. E. encrasicolus dominated the Mark III catches, followed by Ceratoscopelus maderensis and S. aurita, in June and July respectively (Table 4). E. encrasicolus also dominated the bongo catches in both months followed by Myctophidae in June and S. aurita and Serranus hepatus in July (Table 3).

3. Bathymetrical distribution

The bathymetrical distribution of the most abundant species, collected by bongo net, is presented in Table 3. The abundance of the larvae in the 15-30 m depth zone was lower than that in 50-80 m. Species, such as E. encrasicolus, S. aurita and Gobius sp., were concentrated at shallower depths, while other such as Trachurus trachurus and Arnoglossus sp., were found in deeper waters. Vinciguerria attenuata, Zeus faber and Stomias boa boa were found exclusively in the 50-80 m zone. The absence of larval Merluccius merluccius and other Gadidae is striking, although juveniles and adults abound in the area. This is probably related to the summer spawning of hake, a fact resulting to the non-existence of larvae in June and July.

4. Larval length distribution

The analysis of the larval length distribution is important for the estimation of the population abundance and of the timing of reproduction/hatching of fish. The latter will also help the estimation of the timing of the first annulus formation. In general, the length distribution of larvae differed significantly between: (a) regions, (b) time-periods and (c) gears. With respect to Cepola rubescens, S. hepatus, E. encrasicolus, T. trachurus and Gobius sp., the larger individuals were fished with bongo; while for S. aurita, C. maderensis and Coris julis, the larger specimens were collected with Mark III.

The length distribution of E. encrasicolus and S. aurata larvae caught with bongo net in June is similar to that of July (Figures 4 and 5). This is not true of the length distribution of these larvae caught by Mark III (Figures 4 and 5); the abundance was higher in July and their frequency distribution displayed modes at smaller lengths (3-4 mm) as compared with June (Figures 4 and 5). Given the extended spawning season of E. encrasicolus and S. aurita, such seasonal differences in abundance and length distributions may be attributed to dispersal and/or natural mortality. In general, Mark III captures smaller larvae than the Methot trawl (Figures 4 and 5)

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Table 1

Absolute number and average number per filtered metre (m^3) - species combined - over the surveyed area sampling period, June and July 1990, with bongo net

Bongo	Sporades				N. Aegean	
	June		July		June	
Total	Number	Number/m^3 filtered water	Number	Number/m^3 filtered water	Number	Number/m^3 filtred water
Eggs	5 779	1 633	2 361	896	15 190	2 835
Larvae	1 509	375	605	202	2 641	466

Table 2

Absolute number and average number per filtered metre (m^3) - all species combined - over the surveyed areas sampling period, June and July 1990, with Mark III net

Hsp	Sporades			
	June		July	
Total	Number	Number/m^3 filtered water	Number	Number/m^3 filtered water
Eggs	373	2 552	232	2 677
Larvae	211	1 045	185	1 883

Table 3

Average concentration of fish larvae per 100 m^3 sampled
by bongo end Mark III nets (Hsp)
(in June and July 1990)

Species	Sporades				East Aegean	Species	Sporades				East Aegeen
	June		July		June		June		July		June
	Bongo	Hsp	Bongo	Hsp	Bongo		Bongo	Hsp	Bongo	Hsp	Bongo
S. Aurita	7.5	19.2	34.7	277.6	3.9	Trachurus sp.	11.6	22.3	11.6	43.5	24.3
E.encrasicholu	33.2	188.4	51.3	933.6	136.9	M. barbatus	-	-	-	-	3.5
Cyclothone sp.	1.0	3.8	-	-	0.2	P. pagrus	0.8	-	3.1	-	0.7
M. muelleri	-	-	-	-	0.5	Sparidee sp1	-	-	-	-	6.5
V. attenuata	0.4	6.1	-	-	0.2	Sparidae sp2	1.8	-	-	-	8.6
S. boa	0.2	-	-	-	0.2	Sparidae sp3	-	-	-	-	0.2
C.manderensis	16.0	195.4	2.5	27.9	88.1	C. chromis	-	4.9	-	-	0.7
Diaphus sp.	0.4	-	-	-	0.7	C. julis	5.0	60.9	-	-	19.4
Hygophum sp1	46.3	82.5	11.3	103.0	45.2	S. melops	2.4	29.5	-	-	6.3
Hygophum sp2	12.7	54.6	-	27.5	3.2	L. caudatus	3.8	14.1	1.2	19.2	1.3
Lobianchia sp.	1.7	10.2	-	-	-	Scombridae sp1	8.7	-	-	-	4.8
M. puctatum	13.9	-	-	7.0	2.1	Scombridae sp2	7.5	77.1	-	-	2.9
S. phlegon	0.4	-	-	-	0.5	Gobius sp.	39.3	10.8	4.2	41.4	23.6
M. merluccius	-	-	-	-	0.4	Callionymus sp.	20.2	3.6	2.5	25.5	0.6
Z. faber	-	-	-	-	0.2	Blennius sp.	0.9	-	-	-	1.1
C. aper	0.2	-	-	-	0.6	C. ecus	-	-	-	18.8	1.1
C. ruber	1.0	-	0.5	-	0.6	S.sphyreena	-	3.6	-	-	-
S. cabrille	3.3	5.5	0.2	21.0	9.7	Scorpaene sp.	-	-	-	-	0.2
S. hepetus	13.5	44.8	31.8	81.1	28.1	L. cavillone	1.1	-	-	-	0.8
D. labrax	-	-	-	-	0.2	Arnoglossus sp.	38.2	9.9	7.3	39.2	4.1
C. rubescens	5.2	28.0	6.9	15.7	6.3	S. solee	0.4	-	-	-	-

Table 4

Bathymetrical distribution of larvae caught by bongo net
during both sampling stations, in June and July 1990, in the North and West Aegean Sea

Depth 15-30 m		Depth 50-80 m	
Species	Number/m^3 filtered water	Species	Number/m^3 filtered water
Arnoglossus sp.	10	Arnoglossus sp.	39
Blennius sp.	1	Blennius sp.	1
Callanthias ruber	0.23	Callanthias ruber	2
Callionymus sp.	1	Callionymus sp.	23
Carpros aper	0.21	Capros aper	1
Cepola rubescens	6	Carapus acus	1
Ceratoscopelus maderensis	25	Cepola rubescens	16
Chromis chromis	0.69	Ceratoscopelus maderensis	82
Coris julis	11	Coris julis	14
Cyclothone sp.	0.39	Cyclothone sp.	1
Engraulis encrasicholus	153	Diaphus sp.	1
Gobius sp.	20	Dicentrarchus labrax	0.18
Lepidotrigla cavillone	2	Engraulis encrasicbolus	68
Maurolicus muelleri	0.46	Gobius sp.	47
Merluccius merluccius	0.23	Lepidopus caudatus	6
Mullus barbatus	2	Lepidotrigla cavillone	1
Myctophidae sp.	18	Labianchia sp.	2
Pagrus pagrus	2	Merluccius merluccius	0.18
Sardinella aurita	34	Mullus barbatus	2
Serranus cabrilla	4	Myctophidae sp.	112
Serranus hepatus	25	Pagrus pagrus	2
Sparidae sp.	12	Sardinella aurita	12
Symphodus melops	5	Scombridae sp.	18
Syngnathus phelegon	0	Serranus cabrilla	10
Trachurus trachurus	9	Serranus hepatus	49
		Sparidae sp.	6
		Stomias boa	0
		Symphodus melops	3
		Syngnathus phlegon	1
		Trachurus trachurus	36
		Vinciguerria attenuata	1
		Zeus faber	0.20

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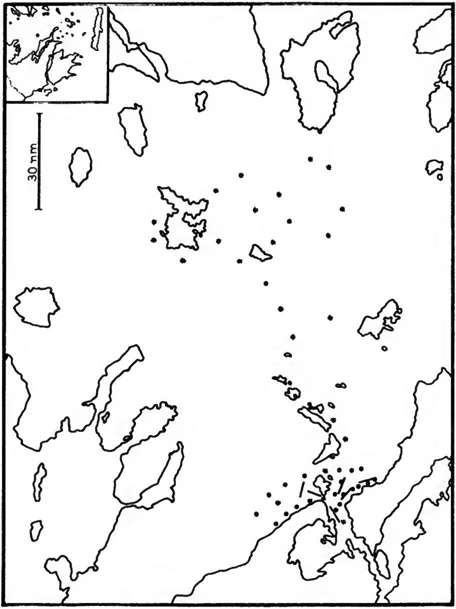
Figure 2. Geographical distribution of E. encrasicolus in June and July 1990 in the West Aegean Sea. (a) June-Bongo net, (b) July-Bongo net, (c) June-Mark III, (d) July-Mark III.

Figure 3. Geographical distribution of S. aurita in June and July 1990 in the West Aegean Sea. (a) June-Bongo net, (b) July-Bongo net, (c) June-Mark III, (d) July-Mark III

Figure 4. Length frequency distribution of E. encrasicolus sampled by Bongo and Mark III (Hsp) in (a) June and (b) July 1990

Figure 5. Length frequency distribution of S. aurita sampled by Bongo and Mark III (Hsp) in (a) June and (b) July 1990



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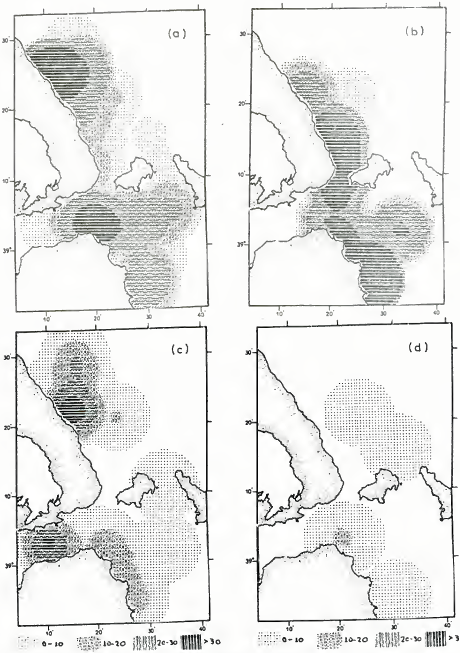

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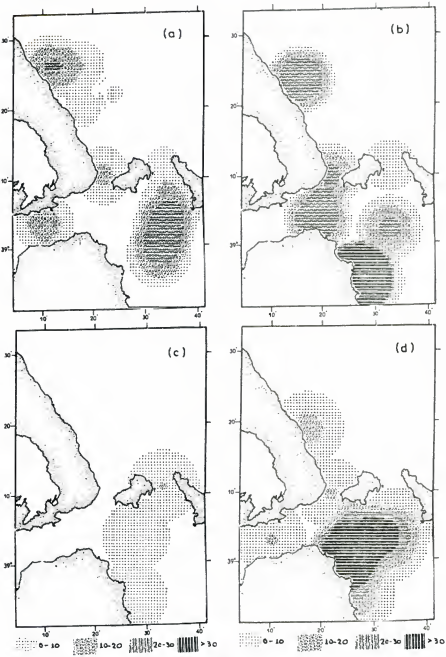

Figure 3. Geographical distribution of S. aurita in June and July 1990 in the West Sea Aegean
(a) June-Bongo net, (b) July-Bongo net, (c) June-Mark III, (d) July-Mark III

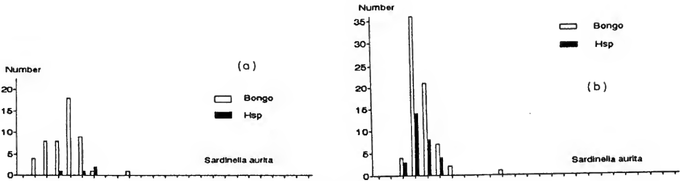

Figure 5. Length frequency distribution of S. aurita sampled by Bongo and Mark III (Hsp) in (a) June and (b) July 1990

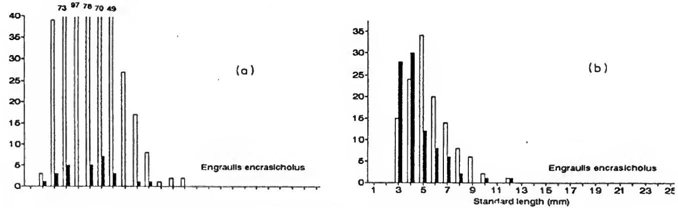

Figure 4. Length frequency distribution of E. encrasicolus sampled by Bongo and Mark III (Hsp) in (a) June and (b) July 1990

ANNEX 12

VIRTUAL POPULATION ANALYSIS AND COHORT ANALYSIS OF HAKE IN THE NORTH AEGEAN SEA

by

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1. INTRODUCTION

1.1 Virtual population Analysis

Virtual population analysis (VPA) is a procedure for determining how many fish there must be in the sea to account for a known catch and to make allowances also for natural losses.

It is based on the solution of the formula (Gulland, 1965):

$$\frac{N_i+1}{C_i} = \frac{(F_i+M)e\text{-}(Fi+M)}{F_i(1\text{-}e\text{-}(Fi+M)} \qquad (1)$$

If N_i+_1 at age i+1, catch C_i at age i and natural mortality M are known it is possible to estimate from equation (1) the fishing mortality at age i, F_i. Equation (1) does not yield an analytical solution for F_i; it has to be solved numerically, either by use of a table or by use of an iterative procedure. Consequently, based on the equation $N_{i+1}+Nie\text{-}(Fi+M)$ an estimate of N_i can be obtained, and so on. In order to start the procedure it is necessary to estimate the number of fish at the oldest age at which the year class was fished.

1.2 Cohort analysis

Cohort analysis (Pope, 1972; Jones, 1981) is a very good approximation to the VPA technique. It is based on the equation:

$$N_i=(N_{i+1})eM+(C_i)e(M/2) \qquad (2)$$

For a given M and after estimating N_{i+1} (as in VPA) N_i can be estimated from equation (2), and so on.

The two methods are used for the estimation of the instantaneous rate of fishing mortality F and of the population numbers surviving at each age. Input data consist of estimates of numbers caught at successive ages of a year class, an estimate of natural mortality and an estimate of fishing mortality at the terminal age of exploitation. The catch-at-age data can be numbers at age of one year from a stock exploited under equilibrium conditions.

2. VPA AND COHORT ANALYSIS OF HAKE IN THE NORTH AEGEAN SEA

2.1 Available data

VPA and cohort analysis have not been applied to data from the Greek seas because of the lack of catch-at-age data. In the present work both techniques are used for the estimation of the population size and fishing mortality of hake in the North Aegean Sea (Figure 1).

The data available are: (1) the total commercial catch of hake in the study area (taken from the Bulletins of the National Statistical Service of Greece); (2) the seasonal age distribution of hake (Figure 2) as derived from four experimental cruises in the North Sea from June 1990 to March 1991; (3) the average length and weight of hake per season and per age; and (4) the natural mortality of hake.

2.2 Assumptions

This analysis is based on the following assumptions: (i) the population of hake in the North Aegean Sea is in a steady-state; (2) the age distribution of the examined samples is representative of the total hake catch; however, there are differences between the age distribution of hake caught by longlines, trammel nets and trawl nets; (3) the age distribution of the samples fished in June represents the catch-at-age distribution for May, June and July; in September for August, September and October; in December for November, December and January; in March for February, March and April; (4) the monthly distribution of the commercial catch of hake in the study area is similar to that of the total hake catch in Greek waters (Figure 3).

3. RESULTS

The total commercial catch of hake in the study area increased from 275 t in 1982 to a maximum of 479 t in 1985 and decreased sharply to 174 t in 1987 (Figure 4). The same is also true of the total fish catch in the study area (catches increased from 8 787t in 1982 to 16 151 in 1985 and dropped to 9 726 t in 1987). The mean (1982-87) commercial hake catch in the study area made up 3.2% of the total fish catch in that area and 12.8% of the total Greek hake catch. Unfortunately, there are no data concerning annual commercial fishing effort in the study area. However, the available catch rates (Figure 4) indicate that hake is probably overexploited in the study area, a fact which agrees with the results of the trawl surveys (Papaconstantinou *et al.*, 1992).

Hake catches exhibit a clear seasonal pattern (Figure 3). Catches are consistently higher in October-May than in June-September when trawling and seining operations are not allowed in Greek waters.

No commercial data are available for 1988-91. Hence, in the present study, an estimate of the 1990 commercial catch was used as the mean catch in 1982-87 which amounted to 367 334 kg. According to assumptions (2) and (4), the June sample is representative for 67 148 kg, the September sample for 66 496 kg, the December sample for 119 953 kg and the March sample for 114 737 kg (Table 1).

From the total weight of the catch, the age distribution and the average weight per age, the numbers of hake per age and per season (Table 2) were estimated.

Based on the empirical formula of Pauly (1983), the natural mortality of hake in the study area was found to be M = 0.17 (Papaconstantinou et al., 1992). and fishing mortality at age 8, F_8 (terminal mortality), was assumed to be 0.6. The results of VPA [equation (1) solved iteratively] and cohort analysis are shown in Tables 3 and 4.

The "number attaining" and fishing mortality do not differ significantly between the two methods (Tables 3 and 4). Fishing mortality is 0.53 for age 0 and ranges between 0.71 and 0.86 for ages >0, with the exception of $F_6 = 0.50$. The estimated total number of fish, survival, number of fish caught and number of fish removed by natural causes are compared in Figure 5 with those of a hypothetical situation for which $F_0 = 0.2$, $F_1 = 0.5$, Ft = 0.7 for ages >1. The changes in the total number of fish and total biomass [=(number of fish)x(average weight)] for the two situations are also compared in Figure 6.

The MSY (= 0.5ZB; Gulland, 1983) is 328 t for the present fishing pattern and 503 t for the hypothetical one. It is clear that a decrease in the number of fish caught at age 0 (the majority of which are discarded) and at age 1 will lead to a significant increase in catch weight (about 55%). Hence, an increase in the mesh size at the cod-end may be beneficial for the Greek hake fishery.

This analysis was based on an estimate of natural mortality M = 0.17 for all ages. However, multispecies VPA experiments in the North Sea suggest (J. Caddy, per. comm.) that natural mortality at ages 0+ and 1+ is significantly higher than that of the adults. Hence, biomass and MSY for $M_{0+} = 1$ and M1+ = 0.5 was also estimated. In this case, the number attaining is 17 192 940 for age 0+ and 4 658 713 for 1+. In addition, total biomass is 976 and 1 201 t and MSY 465 and 553 t for the present and the hypothetical situations respectively.

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Table 1

Seasonal commercial catch distribution (Kg) of hake
in the North Aegean Sea (1982-87)

Summer	Autumn	Winter	Spring	Total
67 148	66 496	119 953	114 737	367 334

Table 2

Number of hake caught per age and per season
from June 1990 to March 1991

Age in yr	Season				
	Autumn	Winter	Spring	Summer	Total
0	543 556	1 430 191	446 616	326 763	2 747 125
1	134 628	310 177	1 109 123	299 807	1 853 735
2	130 868	193 754	179 269	121 139	625 030
3	66 580	137 358	52 188	41 996	298 122
4	28 154	41 656	28 819	18 656	114 285
5	8 621	15 594	8 973	7 397	40 584
6	4 677	641	4 212	2 959	12 488
7	0	4 700	2 014	1 972	8 686
8	0	1 923	2 380	1 151	5 454

Table 3

Cohort analysis of hake in the North Aegean Sea

Age Yr	Number Caught	Number attaining	S_t	Z_t	F_t	Average Number
0	2 747 125	7 324 595	0.50	0.69	0.52	5 279 705
1	1 853 735	3 656 235	0.38	0.97	0.80	2 337 548
2	625 030	1 381 958	0.43	0.85	0.68	931 701
3	298 122	591 812	0.38	0.97	0.80	379 622
4	114 285	225 462	0.38	0.97	0.80	144 162
5	40 584	85 242	0.41	0.90	0.73	56 193
6	12 488	34 639	0.51	0.67	0.50	25 262
7	8 686	17 753	0.39	0.93	0.76	11 553
8	5 454	6 999			0.60	6 999

Table 4

VPA of hake in the North Aegean Sea

Age in yr	Number caught	Z_t	F_t	Number attaining
0	2 747 125	0.70	0.53	7 247 821
1	1 853 735	0.97	0.80	3 613 078
2	625 030	0.85	0.68	1 366 541
3	298 122	0.96	0.79	584 922
4	114 285	0.97	0.80	222 997
5	40 584	0.90	0.73	84 454
6	12 488	0.67	0.50	34 396
7	8 686	0.92	0.75	17 642
8	5 454	0.77	0.60	6 999

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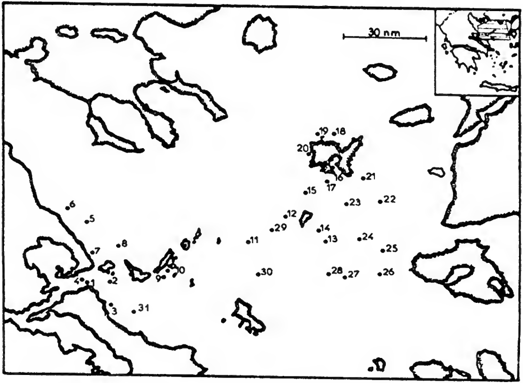
Figure 4. Commercial catch of hake in the study area, 1982-1987

Figure 5. Total number, survival, numbers of hake caught and numbers of hake removed by natural causes for two fishing patterns: present (left bars) and hypothetical (right bars) for which $F_0 = 0.2$, $F_1 = 0.5$ and $F_t = 0.7$ for ages $t>1$ (see text)

Figure 6. Numbers and biomass of hake per age for two fishing patterns: present (1) and hypothetical (2) for which $F_0 = 0.2$, $F_1 = 0.5$ and $F_t = 0.7$ for ages $t>1$ (see text)



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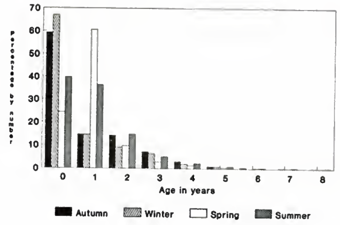

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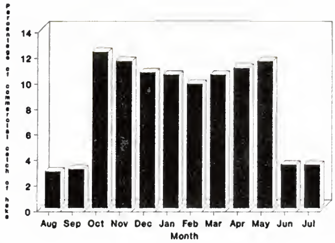

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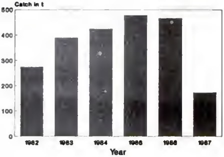

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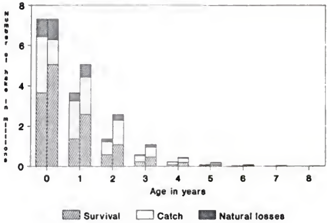

Figure 5. Total number, survival, numbers of hake caught and numbers of hake removed by natural causes for two fishing patterns: present (left bars) and hypothetical (right bars) for which $F_0 = 0.2$, $F_1 = 0.5$ and $F_t = 0.7$ for ages $t > 1$ (see text)

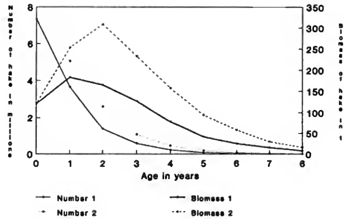

Figure 6. Numbers and biomass of hake per age for two fishing patterns: present (1) and hypothetical(2) for which $F_0 = 0.2$, $F_1 = 0.5$ and $F_t = 0.7$ for ages $t > 1$ (see text)

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